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2nd Annual
NATIONAL CONFERENCE ON RADIATION CONTROL

The Quest for Quality

April 26-29, 1970 • Palm Beach, Florida

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	Title	
ORO 69-1 69-2	Directory of Personnel Responsible for Radiological Health Programs, January and July 1969. (out of print)	
ORO 69-3	Report of State and Local Radiological Health Programs, Fiscal Year 1968	PB 188-262
ORO 69-4	Conference on Federal-State Implementation of Public Law 90-602, March 24-26, 1969, Montgomery, Alabama	PB 189-655
ORO 69-5	Radiation Sources in Secondary Schools. Report of a Limited Survey, 1969	PB 188-701
ORO 70-1	Directory of Personnel Responsible for Radiological Health Programs, February 1970 (out of print)	
ORO 70-2	State Radiation Control Legislation - 1969	PB 193-154
ORO 70-3	Directory of Personnel Responsible for Radiological Health Programs, July 1970	
ORO 70-4	Report of State and Local Radiological Health Programs, Fiscal Year 1969	PB 193-929
ORO 70-5	2nd Annual National Conference on Radiation Control, April 26-29, 1970, Palm Beach, Florida	

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2nd Annual NATIONAL CONFERENCE ON RADIATION CONTROL

The Quest for Quality

April 26-29, 1970 • Palm Beach, Florida

Cochairmen:

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Office of Regional Operations
Bureau of Radiological Health
Rockville, Maryland

and

T.M. Gerusky, Director
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State Department of Health
Harrisburg, Pennsylvania

October 1970

Sponsored By

Conference of Radiation Control Program Directors

and

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of Radiological Health
Rockville, Maryland 20852

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FOREWORD

The Bureau of Radiological Health continues to carry out a national program designed to reduce man's exposure to ionizing and nonionizing radiation.

Within the Bureau, the Office of Regional Operations assists and advises the Bureau Director on regional and State radiological health activities. This office coordinates all radiological health activities for the active Federal-State partnership to achieve and maintain comprehensive radiological health control. The Office of Regional Operations also guides and directs the State participation in Public Law 90-602.

The Bureau publishes its findings in "Radiological Health Data and Reports" (a monthly publication), Public Health Service numbered reports, appropriate scientific journals, and technical report series for the Bureau's divisions, offices, and laboratories.

The technical reports of the Office of Regional Operations (ORO) allow comprehensive publishing of the results of intramural and contractor projects. The reports are distributed to State and local radiological health personnel, Bureau technical staff, Bureau advisory committee members, university radiation safety officers, libraries and information services, industry, hospitals, laboratories, schools, the press, and other interested individuals. These reports are also included in the collections of the Library of Congress and the National Technical Information Service.

Your additional comments on these reports or requests for further information are encouraged.

John C Villforth

John C. Villforth
Director
Bureau of Radiological Health

PREFACE

The Bureau of Radiological Health has been established as the focal point for radiological health activities within the United States Public Health Service. The Bureau's Office of Regional Operations has been assigned the responsibility to disseminate technical information to States, review and compile Federal-State legislation, and assist State program development, maintenance, and expansion.

As a mechanism to expand and improve communication between State and Federal radiological health programs, the Bureau of Radiological Health and the Conference of Radiation Control Program Directors jointly sponsored the Second Annual National Conference on Radiation Control, April 26-29, 1970, in Palm Beach, Florida.

This publication contains the proceedings of that Conference. The Conference agenda was divided into general sessions to consider important radiation control issues. In addition, Committees of the Conference of Radiation Control Program Directors met to consider and make recommendations on specific problem areas.

One hundred and fifty-nine persons, representing State and local radiation protection programs, the U. S. Atomic Energy Commission and the Bureau of Radiological Health attended this most successful meeting.

Our gratitude is extended to all participants of the Conference and especially to the officers of the Conference of Radiation Control Program Directors and its Committee Chairmen who contributed so much to its success.

James W. Miller

James W. Miller, D.D.S.
Director
Office of Regional Operations

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ABSTRACT

This publication contains the proceedings of the Second Annual National Conference on Radiation Control, April 26-29, 1970 in Palm Beach, Florida. This meeting was cosponsored by the Bureau of Radiological Health, U. S. Public Health Service and the Conference of Radiation Control Program Directors.

The Conference concentrated on three major problem areas in radiological health: (1) public exposure to x radiation, (2) improving the qualifications of radiation users and (3) environmental radiation around nuclear facilities. In addition to formal presentations by State, local and Federal representatives, Committees of the Conference of Radiation Control Program Directors met and reported on specific radiation control programs.

SUMMARY

Radiation protection problems arising from expansion in the use of x rays in the healing arts, continued growth in the use of electronic products emitting ionizing and nonionizing radiation and the increasing use of nuclear energy in electric power production dominated sessions of the Second Annual Conference of Radiation Control in Palm Beach, Florida, April 26-29, 1970.

In addition to formal presentations by State, local, and Federal representatives, members of the Conference of Radiation Control Program Directors met in committee sessions to recommend actions and positions on specific radiation control problems. Details of the Committee reports are included in the proceedings. The highlights of those recommendations are summarized below.

1. Medical x-ray exposure continues to be the most important issue in radiation protection followed by environmental ionizing radiation and nonionizing radiation from electronic products.

2. More conformity and compatibility in regulatory and compliance activities of radiation control programs are needed. These can be accomplished by mutual trust, adoption of model regulations, improved communications by holding annual conference meetings and by continuing committee action.

3. Reciprocity action between States is indicated for the following areas: (a) licensing of "nonagreement" radioactive material; (b) certification of x-ray technologists; (c) medicare certification of x-ray facilities; (d) x-ray facilities utilizing used x-ray equipment; (e) industrial radiographic operations.

4. Bureau of Radiological Health and manufacturers should establish uniform training standards and provide training information on radiation protection for installers and repairmen. Such information should be placed in operating and servicing manuals and on the equipment itself. A most critical need is for educational material expressed in simple terms with a minimum technical jargon.

5. Bureau of Radiological Health should provide training courses for personnel servicing or installing high hazard electronic products.

6. States need to develop regulations covering personnel who install or service electronic products that emit radiation.

7. States should require that vendors of electronic products be responsible for notifying the State of installations and for certifying to the purchaser that the product meets appropriate State regulations.

8. States should require prior registration and plan approval for high-hazard radiation producing equipment.

9. States should adopt model regulations and legislation as available to achieve uniformity.

10. Subsequent to adoption of performance standards for each type of electronic product, BRH, in cooperation with the Conference of Radiation Control Program Directors, should develop model State regulations covering the use and users of such products.

11. Legislation should be pursued to provide authority to U.S. Department of Health, Education, and Welfare to regulate and control radioactive material not controlled by the U.S. Atomic Energy Commission.

12. The Conference of Radiaton Control Program Directors should establish an evaluation group to evaluate the effectiveness of individual State programs upon request. Basic evaluation criteria should be developed and adopted by the Conference to facilitate such evaluations.

13. A model data processing system for use by State x-ray control programs should be developed by Bureau of Radiological Health.

14. Bureau of Radiological Health, in cooperation with States, should develop and provide in-service training for x-ray technology instructors.

15. State certification programs for radiologic technologists should require continuing education of at least eight hours per year for practicing technologists.

16. States should form a nuclear facility site evaluation committee and conduct preoperational as well as operational environmental surveillance to obtain base line data and an inventory of radioactive waste discharged from specific nuclear facilities in preference to general environmental surveillance. Such activities should be funded in part by those who contribute to radioactive waste releases to the environment.

Due to the need for further considerations, the Committees requested that they be named continuing committees to work throughout the year prior to the next annual Conference.

SECOND ANNUAL NATIONAL CONFERENCE ON RADIATION CONTROL

INTRODUCTORY REMARKS

The Second Annual National Conference on Radiation Control convened in the Churchill Room, Holiday Inn, Palm Beach, Florida, Sunday, April 26, 1970, and was called to order at 3:07 p.m. by Dr. James W. Miller, Chairman.

DR. MILLER: It is a real honor to once again co-chair a meeting of the National Conference on Radiation Control with Tom Gerusky. I believe we accomplished quite a bit at our last meeting. I have never seen a more dedicated and hard-working group. I am sure this meeting will be just as productive.

The theme for our Conference is "The Quest for Quality." Webster's Dictionary defines "quest" as seeking adventure. Many of us in radiological health feel that our work is an adventure, but in addition, it is a challenging and an exciting area of public health.

Webster further defines "quest" as those who make a search collectively. This, I believe, more appropriately defines what we are doing with the relationships that have been established between the local, State and Federal programs in radiological health.

There are quite a few definitions for "quality" in the dictionary, but the one we liked the best was excellence. Searching collectively for excellence is a very appropriate theme for this Conference in recognition of the effort that has gone into radiation control by all of you. This includes local, State, Federal and private sectors, various professional groups and industry.

In this area of public health more than any that I am aware of, there is this feeling of cooperation and working together to get a job done.

Before starting with our program, I believe recognition is due the individuals who are responsible for the local arrangements and the program.

Dr. Sowder, Director of Florida's Division of Public Health, deserves special recognition along with Dr. Nayfield, Administrator for the Radiological and Occupational Health Section of the Florida Division of Public Health.

Heinz Wilms from the Office of Regional Operations, Bureau of Radiological Health, has done a tremendous amount of work on the program.

And last, but not least, Dr. Brumback, Director of the Palm Beach County Health Department who recommended this choice location and was responsible for all the local arrangements. Dr. Brumback called this morning to advise me that Dr. Bax who was to give the welcoming remarks and to introduce our principal speaker this afternoon had become ill. I prevailed on him to welcome us to this lovely spot and to start this Conference by introducing our principal speaker for this afternoon.

He agreed, and I would like to give you now Dr. Brumback.

WELCOME

C. L. Brumback, M.D.[1]

Congressman Rogers, Dr. Peterson, Radiation Control Program Directors and Guests: Dr. James Bax, the Secretary of the Florida Department of Health and Rehabilitative Services, sends his sincere regrets that he was unable to be here today. And I am sorry that you will not have the opportunity of hearing Dr. Bax at this time. He has done an outstanding job of developing our new Department of Health and Rehabilitative Services which combines a group of related governmental functions here in Florida.

This Department is a product of much needed reorganization of Florida's State Government recently effected following Constitutional revision.

Representing Dr. Bax, I am pleased to welcome you to Florida and to Palm Beach County. For those of you who are here for the first time, I think we have something in common. This is our first experience having a National Conference on Radiation Control. We have interceded with the weatherman, and I hope he will do his best for us.

I also hope that you will have an enjoyable as well as profitable stay here. Please call on us for any assistance that we may be able to give you.

Now, it gives me a great deal of pleasure to introduce your first speaker, the Honorable Paul G. Rogers, Representative in Congress from the Sixth District in Florida. Mr. Rogers has served as a Member of Congress since January 1955. In this, his home district, he needs no introduction.

Now, after 15 years of distinguished service in Congress, we may say that he needs no introduction to most of you. This is especially true in speaking to a health group.

Mr. Rogers is a national leader in public health legislation. Notable among his achievements as author of bills or assisting in their drafting are those significant acts pertaining to mental health, mental retardation, health planning, vocational rehabilitation assistance, migrant health and community health facilities. Among his recent assignments has been the chairmanship of the Special Investigations Subcommittee for the Department of Health, Education, and Welfare.

It is my pleasure to present Congressman Rogers.

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[1] Director, Palm Beach County Health Department, Palm Beach, Florida.

THE CHALLENGE OF RADIATION CONTROL

Honorable Paul G. Rogers[1]

Thank you very much, Dr. Brumback. It is always good to have a friend introduce you. And Carl has been a good-time and a long-time friend. I appreciate his being here and his cordial introduction.

I am delighted to be here and to commend you for holding this Second National Conference on Radiation Control and its problems.

I have looked through your program, and I am delighted to see the emphasis that you are giving to the various phases of this whole program of radiation control, tying it in more thoroughly with the environmental problems. Certainly, this is a very wise thing. I would anticipate that in the 1970's--and I am going to do what I can to help bring this about--we should see increased activity program-wise and funding for radiation control programs.

You know, actually, my interest was first activated when we had the color TV radiation scare which you all remember. We had previously gone into that problem with the Public Health Service, and they told me, "No, they didn't think there was any problem."

I started checking into it a little bit. And about the time I started checking into it and was drawing legislation to introduce, feeling there was some problem, all of a sudden, General Electric came to the fore and said, "150,000 of our color TV sets are emitting radiation."

Well, that got the problem exposure and a little notice. And this is what we need today in this area. That has been one of the problems of fighting radiation hazards. Nobody ever sees it. You go to the doctor, and you get an x ray. Well, you don't see it. You open that microwave oven, and you smell or you look at what is cooking. Or you watch TV. You can go right down the line. The public has had no dramatic exposure to this whole problem, and as a result, it was hard to get support or even public recognition that there is a problem.

We even had a professor here at Florida Atlantic University, and I don't recall his name, who said, "Oh, there is no problem there; Rogers doesn't know what he is talking about when he introduced his bill." I am glad to say that some of you scientists who have done a little research backed us up over there in the Congress and have shown that there definitely is a problem. It is an environmental problem along with the others that we have of air pollution, water pollution, solid waste pollution and radiation pollution. Maybe we ought to approach it on that angle of radiation pollution to get some public exposure here.

---

[1] Member, U. S. House of Representatives.

We need to do this to bring this program into a proper perspective. To the American public, radiation has been kind of a some-time thing for specialists. No one has really brought it home to them yet.

So perhaps strange as it may seem, it was a good thing for all of us concerned with radiological health that we had the TV scare, because that in reality brought it into the home of every American. They became concerned and that concern expressed itself in legislation and in the fact that the President of the United States in his State of the Union Message called for radiological control. That helped all of our departments who all of a sudden said, "Yes, we think it is good."

Strange how a word or two from the White House changes lots of attitudes. But it has happened. Now, we need to start making some real progress. I don't think we have made enough, and I am troubled still with the lack of concern and the lack of knowledge in this whole field.

We passed the law two years ago, 1968. I just read a little item in the paper the other day--perhaps you did, too--that Dr. DuBridge, the President's Science Advisor, said that we need more electrical power. Well, he is right.

He said, therefore, we should not mind a little bit of radiation given off by nuclear power plants. Well, you know that points up the lack of knowledge, and doubly so considering the source of that statement. Here is a man advising the President of the United States.

Well, we know we have got the problem. What are we going to do about it?

Manpower. When we look at what has happened in the manpower field, we see we are dramatically short. In fact, the Bureau of Radiological Health in 1968 when we passed the Act had about 711 persons. Do you know what they had in 1969? It dropped from 711 to 674. Some of that was due to the action of the Congress and the tightening of the fiscal belt because of inflation.

But for 1970, the requested authorization employment level went to 631. So we see that we have increased the work load on what they have got to do, the responsibility has been increased, and manpower resources have been reduced by 10 percent. Certainly, I am sure this goes for the States as well.

I don't think it is a very encouraging picture on what has happened there. The same manpower was working in the field at about the same level as it was five years ago in most places. In fact, I have even seen examples where they have one man in a State handling radiological control. One man. So I think that points up the problem that we have in manpower.

Now, on the financial side, you take the Bureau of the Budget and the Administration. They can cast long shadows even into out-of-the-way hearing rooms on Capitol Hill. It is my feeling that the Bureau and the Department of Health, Education, and Welfare, Mr. Surgeon General, have really not been vigorous enough in pursuing funds for radiological health. We know there have been restraints. But we have not been vigorous enough in requesting the necessary funds from the Congress to get the job done.

Now, the request in 1971 is approximately $13.1 million. Well, that sounds like a pretty good bit of money. But when we start comparing it, then we put it in a proper perspective. Do you know what it was in 1968? $11.6. 1969 was $11.7, and in 1970, $12. Well, you know the way this inflation is going, increased salaries and so forth, $13 million is really a backward step, not an increase.

Research funds have dropped from a high of $2.5 million in 1966 to $1.7 million in 1970, which is also the estimate for 1971. Again, proof of a lack of priorities and a lack of aggressiveness.

This applies also to the training grant area for long-term graduate instruction. We find similar cut-backs from a high of about $2.25 million in 1967 to $1.75 million in 1969. 1971 will be about a half million under that.

Now, we know we need additional personnel, and we need training. But we are not even requesting what is necessary to meet the need. If you will recall the Radiation Control Act that I had the pleasure of authoring stressed training in a very specific way. We intended that we ought to increase training in order to bring about a minimizing of emissions and exposure to people.

We also need to do so much more in research, nonionizing as well as ionizing. It was hard for us to get the experts to tell us before the committee whether it was cumulative or not, ionizing radiation. One would say yes, one would say no. Well, they are not sure. There are many questions we don't know the answers to, and we are not doing sufficient research yet to find the answers. We are just beginning, and we don't know them yet. And yet, we are not putting up enough funds to do the kind of job that needs to be done.

Now, if we are going to set any performance standards and get devices in order to tell us whether the standards are being met, we might as well make up our minds that we are going to have to have some funds and some personnel, some research and some training. This is the story that I hope all of you will carry back and that we have got to carry all over this country and begin to alert people.

And you ought to call it radiation pollution so they will understand it. They will say, "Oh, well, you have got all this background pollution so this problem is not so much." Well, we have got to put all this in a proper perspective where people can understand it very clearly.

Then, we have got to set performance standards. I know it is simply not a matter of just setting down some numbers, so many milliroentgens or so many milliwatts. It is going to have to also be tied in with compliance, inspection, enforcement, and recordkeeping. What are we going to do about imports and handling the defects and whether we have recall in what regard? There are so many things that need to be done here.

I also hope we can put the Federal program where we can begin to assign more freely some of the Federal people to be helpful to the States. We haven't done a very good job there yet.

And, of course, the States are going to have to assume a greater responsibility. They don't even certify or require licensing of people who handle this equipment now. We are going to have to face up to this. This is inevitable. It has got to come. And we might as well get on with the program having experts handle this type of equipment.

Some of the facts that were given us back in 1968 said that over half of the medical devices, x-ray machines, are not functioning properly, not being handled correctly--too wide beams in many places, cones taken off, unbelievable things, no protections provided, and no reason for it except that we haven't required that it be done.

So I would say there are about five things that need to be done:

First, securing additional funding and support in Federal and State programs. This is the whole field of radiation, including adequate inspection and compliance efforts.

Secondly, there is a need for employing greater Federal manpower in support of our State radiological programs.

Thirdly, to increase Federally supported training programs. And I include nonionizing radiation which is covered in the law, but with a strong emphasis, of course, on the traditional areas of radiation concern.

And, fourth, of course, there is a need for increasing biological effects research efforts.

Lastly, we must direct attention to problems relating to licensing and certification of technicians or other users of radiation as in medical x radiation as well as for the TV repairmen and microwave oven repairmen.

I am glad the report is due in about two weeks on that microwave business. I think we are getting into this before the American people really are zapped with them.

We have got about 40 or 50,000 in homes now and maybe as many as 100,000 microwave ovens altogether, and I think you are going to see this market really expand. We have now the right steps being taken so we can get at this problem before they inundate the American public. I think now that we are going to see increased use of all of these electronic products. So we are coming in at a time when we can give some real protection to the American consumer if we will do it.

Finally, let me conclude by saying this: In the Congress, we have had to devote a great deal of time this year, particularly the first part of this year, to hearings on health legislation. We have had about 13 or 14 laws that are on the books that are expiring by the fiscal year which will be June 30.

We have just finished our hearings on air pollution, finished mental health, and mental retardation. We are going into comprehensive health planning very shortly, regional medical programs, as well as others. But as soon as we get through these, I am going to see if the Committee can't devote some of its time, Dr. Peterson, to really looking at what is going on in the radiological field.

We haven't had much time to do this since we passed the law. But we are going to have some very deep inquiry on what is happening in research in order to see if we can't give it a little emphasis and spurt from the Congress. And we are going to call our experts up and find out what is happening. We hope some of you will participate. We hope that you will come forth with some good suggestions on how we can spread this out over this country, get some activity going in every State, and to get some standards really effectively set and enforced to protect the American people.

It is a great problem that needs to be solved. We have the means of doing it if we will get on with the job, if we will give proper funding and proper manpower support. It can be done. We have the brain power to do it.

I commend all of you for your interest in this field. It is a most important one, and I think you are going to see increased recognition of the jobs you are doing in this country in the decade coming up. If we will all work together in a cooperative effort with the Federal and State governments, and local communities, I am very convinced that we can get on top of this problem before it really gets out of hand.

Another thing I might just mention in conclusion is that for too long we have completely exempted the military installations in everything they do. And we are going to try to change this.

The reason I say that, we just went through that on air pollution. Some of the greatest polluters are the air force bases and naval bases and some of these others. Some of the greatest radiation polluters are the military, too, with all of the communications, with the radar and all of these television and radio stations, not just in the military. But there has been a tendency if it is military to say, "Oh, well, we can't do anything there."

Well, we are just changing that in the air pollution law. We tell them we want them to comply with the local standards. If they don't, they can only get out of it by getting a special exemption from the Secretary of Health, Education, and Welfare. And that is only to be done in serious cases. We want him to report to the Congress when he gives that exemption.

We are going to start doing that if we can in radiology, too, in this problem of radiation. Because I don't think we realize yet what is happening in this area. A few simple, well-ordered steps can correct it. It is not going to put anybody out of commission or out of doing what they have to do. But if everybody else can do it in this country, I think they can, too, and we ought to do it.

It is a real pleasure to be with you. I commend you, and we stand ready to be helpful where we can.

Thank you.

DR. MILLER: Thank you, Congressman, for that very excellent and challenging speech to these dedicated men.

To put it very succinctly, and I believe they would all agree, their main problem is money, people and things. They have the knowledge, the dedication to do the job. What they need is money to provide the resources.

I would like to introduce at this time someone who is not on the printed program because we were not sure he would be able to be here. You all know this gentleman.

Last year, he addressed you as the Acting Director of the Bureau of Radiological Health. This year, he is the Acting Commissioner of the Environmental Control Administration.

The truth of the matter is this gentleman has the unique ability to hold things together in a period of constant change which we seem to be going through in Washington and being able to focus on the job that has to be done. This enables the rest of us to continue on with our work while he is worrying about the problems of reorganization.

This gentleman is Dr. Raymond Moore who will introduce our next speaker.

DR. MOORE: Thank you, Dr. Miller.

Congressman Rogers, Dr. Brumback, Ladies and Gentlemen: It is a distinct pleasure to me to be here with you this afternoon and to participate in a very small way on this program. Listening to Congressman Rogers, I could not help but comment that it is very difficult to follow in his tracks. He is very able, he is very dedicated, and he has been very, very helpful to us bureaucrats over the years.

Sometimes we don't recognize his needling as helping us until the job is done, but it has been very helpful. Thank you very much.

I would like to introduce to you Dr. Paul Q. Peterson. Dr. Peterson is from Illinois. He received his M.D. degree from the University of Illinois, later journeyed to the University of Florida, earning an MPH degree. Dr. Peterson has been a Commissioned Officer in the Public Health Service since 1942. He has had wide public health experience in the States of Kentucky and Ohio as well as at the Federal level in varied international assignments.

Dr. Peterson is quite knowledgeable on matters concerning radiation. He has been very helpful to us in these areas since he has been appointed the Acting Deputy Surgeon General of the United States.

It gives me a great deal of pleasure to introduce to you Dr. Paul Q. Peterson.

PROTECTING THE PUBLIC FROM RADIATION

Paul Q. Peterson, M.D.[1]

Congressman Rogers, Carl, all of those who are attending as participants and as visitors at the Conference: I bring to you Dr. Steinfeld's sincere regrets. On Friday afternoon he called and indicated that because of commitments that had just been assigned to him, he would not be able to be here today.

It happened that I was talking on the phone in Dr. Moore's office, and I turned the phone down and turned to Ray and said, "The Surgeon General will not be able to attend the meeting and present his paper."

And Ray said, "Bring the smelling salts."

I said, "You will need them even worse because I am going to have to take his place."

With this little episode, I would just like to share a personal vignette with you if I might. Over the years, I have had the good fortune of appearing on programs where various of our Surgeons General were unable to be in attendance. And when Dr. Steinfeld appointed me as his Deputy, I thought now these sudden "invitations" that one receives from the Surgeon General to appear on programs will probably not come my way any more.

Let me assure you of two things. First, they still come this way.

Second, the way in which I receive the invitation is entirely different. Now, Dr. Steinfeld calls up and he says, "Come in here. I have a speech, my airplane tickets, my hotel reservations. I hope Mildred--my wife-- will be able to meet you at the airport in time to catch the plane and bring you along some shirts."

I would like, before presenting Dr. Steinfeld's paper to share something with you. Those of you who are not from Washington and have not had the privilege of working with Congressman Rogers and his staff over the years, I am sure caught in his presentation to you the skill that always characterizes every effort that he assumes responsibility for and that characteristic that has brought him to the position where in Congress he is looked upon as one of the ablest and most responsible and knowledgeable people in the entire field of health legislation, of health program review functions, that Congress must continue to perform. It is a great pleasure for me to have the opportunity of sharing the podium with Congressman Rogers and to convey to him the fact that I will alert Dr. Steinfeld, sir, to the fact that we will need to begin to prepare for hearings before your committee with reference to radiological health and to have staff in a position to lay before you the issues, our progress and problems.

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[1] Acting Deputy Surgeon General, U. S. Public Health Service.

It is a real pleasure for me to be with you today for the opening of the Second Annual National Conference on Radiation Control. Assembled here today are the nation's authorities on radiation control--representing all 50 States, the District of Columbia, Puerto Rico, the Virgin Islands and a number of local and Federal agencies, including the United States Atomic Energy Commission, and our own Bureau of Radiological Health of the Environmental Health Service.

You are the people who have the authority and are charged with the responsibility for protecting the public health from the hazards of radiation. You are where the action is. And you have been working on this problem for many years--yes, indeed, long before modern-day "ecologists" knew what the word meant. And you will also be concerned, I predict, with this problem long after the "Don Quixotes" have moved on to begin tilting with another "windmill." Your efforts have been and will always be judged by results, not by promises nor by newspaper clippings.

As we are all painfully aware, these results are often difficult to measure or identify. As professionals in public health, we know why. Radiological health is an excellent example of the ideal public health program of hazard prevention. We cannot wait until biological hazards manifest themselves in nicely measured infant mortality rates or occupational deaths.

We have known since the turn of the century that radiation can cause effects such as burns, cancer, other human ills. We have also discovered that there are genetic effects which are not easily determined and which may not even manifest themselves for a number of generations.

All of these have been compounded by the problem that radiation damage is nonspecific in most cases--indistinguishable from other biological insults such as temperature, chemicals, nutrition, to mention a few. But on balance, the amount of data we now possess for radiation effects exceeds that for many other hazards, even though our sample is fortunately low.

These problems have not deterred the establishment of the prudent philosophy of reducing radiation exposure to levels as low as practicable and the formulation and enforcement of standards that offer the public the benefits of radiation with adequate protection.

However, there is a paucity of concrete figures relating hazard and low radiation dose. This data gap makes it extremely difficult to compete with visible public health problems concerned with insults to people for which drastic immediate correction is needed. I am not suggesting that we relax our standards to get these figures. On the contrary, I believe we in public health have the responsibility to further reduce radiation exposure that serves no useful purpose.

I subscribe to the philosophy on standards quoted by my predecessor, Surgeon General Stewart, that effective standards for health protection must rest on the following conditions:

First, standards should be truly relevant to man's health. We must assure that our standard is addressed to the prevention or control of a health hazard in man's environment.

Second, a standard must be realistic and attainable. A health protection standard must be attainable within the state of the art and at a financial cost which is not truly prohibitive. Otherwise, the standard would become in fact a flat prohibition rather than a charter for prudent continuation of a desirable activity under conditions not injurious to human health.

Third, adherence to a standard should be measurable with reasonable precision and reliability. The enforcer should be able to determine when a violation has taken place, and the enforced, who wish to comply in good conscience, should be able to determine that they are indeed complying.

Fourth, a standard should be aggressive in terms of protecting the public health. Uncertainities as to the degree of control should in general be resolved in the direction which will afford the greatest protection to the public health.

It would be equally wrong for us to arbitrarily prohibit usage and deny the public benefits that radiation can achieve. It is the old game of benefit versus risk which radiological health plays so well. As I see it, we must replace fear with caution and respect, replace ignorance with knowledge and understanding, replace denial with controlled use and acceptance, and replace promises with performance. This is why I am pleased to see that the theme for this year's National Conference on Radiation Control is "The Quest for Quality."

Dr. Miller, I gather that in addition to you, Dr. Steinfeld also used the dictionary because I find he says: Webster defines "quest" as a seeking, an adventure. You were using the same definition.

To me, this implies a continuing search, a dynamic effort. From my own experience with radioisotopes in the Public Health Service from 1951 to 1958, I know that radiation protection is indeed a quest, especially if you have ever discussed a number of noncompliance items with a physician in his private office.

As for quality, Webster offers a number of definitions, but I believe that the most appropriate is "excellence of character; an acquired trait; accomplishment."

The old problems of radiation control continue to be with us. In 1958, the three major challenges presented by radiation were to alert the public to the need for greatly expanded radiological health programs, to obtain an adequate supply of trained manpower, and to increase research into the biological effects of radiation, especially at low dosage level.

The demand for medical radiographic service continues to grow by seven percent each year. It is significant that State and local agencies have inspected over 73 percent of the 108,000 medical x-ray machines in the United States. And over 30 percent of these were inspected in the Fiscal Year 1969 alone.

My congratulations to all of you.

The increased medical use of radioisotopes in the last few years is truly remarkable. Nuclear medicine is growing at an annual compounded rate of 15 percent. Newly available radiopharmaceuticals, sophisticated imaging and detection systems and improved diagnostic procedures have provided phenomenal new ways to accurately diagnose and treat an ever-increasing number of patients.

In view of the rapidly changing and increasing use of radiation in all fields, it is essential that radiation control be equally dynamic, and be responsive to the new complex radiological health problems that are now arising.

In short, radiation control must be a continuing search for accomplishment to prevent unnecessary biological risk. It is truly a challenge as it has been expressed so ably today by Congressman Rogers.

I am heartened by the fact that today, there are definable radiological health activities in all the States and several large cities. I am very pleased that there is the Conference of Radiation Control Program Directors to serve as an effective, viable spokesman for State and local programs, a focal point through which State and Federal efforts may be coordinated. And especially important, an annual meeting of this type, dealing with the radiation control problems we face every day.

I am confident that your dialogue these next few days will result in an even greater quality, greater understanding and greater cooperation between the States and with the Public Health Service.

The Public Health Service needs the States' cooperation in many of its radiological health activities, and the opposite is true. It will come as no shock to you that the responsibilities given to us by the Radiation Control for Health and Safety Act of 1968 far exceed the resources of the Bureau of Radiological Health even though a considerable number of program activities have been adjusted to meet our present and new responsibilities.

I personally have seen the value of cooperation between the Department of Health, Education, and Welfare, the States, and industry in the latest venture--public exposure to radiation from microwave ovens.

As you know, when the problem of microwave ovens was suggested by State surveys in 1969, our Bureau of Radiological Health conducted cooperative field studies with several States on a limited sample of 155 ovens which confirmed the need for investigation and correction.

Concurrently, the Technical Electronic Product Radiation Safety Standards Committee set up by Public Law 90-602, representing Federal, State, industry and consumer interests was considering microwave exposure standards. Some of the Committee members, I understand, are here today in this session.

On January 12, 1970, I convened a special meeting with representatives of Federal, State, local, industry and consumer interests to deal specifically with the microwave oven radiation leakage problem. An Ad Hoc Task Force on microwave ovens was formed to come up with workable solutions. It was clear that neither the Federal Government nor the States could hope to survey all microwave ovens in a reasonably short time, that the problem was just too large for any one agency or one industry to handle.

I am happy to report that the Task Force did its job well and plans are being reviewed and approved to find and correct the defective units. Our Bureau of Radiological Health will be auditing industry's correction program utilizing a number of participating State radiation control programs. This is an excellent example of a Federal-State partnership to protect the public at minimum cost, minimum delay and maximum effect.

The first National Conference in Montgomery, Alabama, last year was, in my opinion, long overdue. I am happy that you plan to continue it on an annual basis. That first Conference came up with a number of important problem areas and priorities for protecting the public from radiation. I wish to list only six of these:

1. The first priority of a radiation control program should continue to be the reduction of unnecessary healing arts x-ray exposure;

2. The need for more support, coordination and compatibility of programs;

3. Programs should be expanded to cover nonionizing as well as ionizing radiation hazards;

4. Uniform control is needed over all types of radioactive material;

5. Environmental surveillance programs should be adjusted to become more oriented to specific environmental sources of radiation; and

6. The need for increased participation by State, Federal and local agencies in the formulation of legislation, regulations and standards.

These statements are an indication of your concern for the total responsiblity to the problem of public radiation protection. And I believe much has been done since last year in implementing these recommendations.

Consider, for example, the new x-ray equipment inspection program, establishment of a radiation incident registry program, the 1970 X-ray Exposure Study to update 1964 data, the input by the Conference of Radiation Control Program Directors into the development of x-ray performance standards, Bureau of Radiological Health and State protocols for microwave oven surveys, critical review and adjustments underway in Federal and State environmental surveillance networks. These are only a few examples that show you did not make those recommendations only for the purpose of putting them on paper, but you have truly demonstrated through performance that you meant them.

This spirit of mutual concern and action is reflected in the agenda for this Second Annual National Conference on Radiation Control. I congratulate you for putting together a meeting which comes to grips with the real problems facing radiation control programs today.

I wish I could present to you a number of solutions to these problems, but that is why you are here. Who else could better provide the solutions than you?

We in the Federal establishment must not forget the responsibility and authority of the States for controlling the safe use of radiation. The Federal Government in turn has a responsibility to insure that electronic products as well as other sources of radiation meet reasonable, effective and necessary performance standards. To be effective, State and Federal responsibilities must be compatible, not competitive. The Administration's emphasis on the "New Federalism" assures a fuller role for State and local government participation.

I also wish I could promise to provide you with all the resources we now lack to meet the challenge of radiation control. Only, however, through the action that we are able to secure from the Administration and from the Congress and from the State legislatures will we be able to achieve that goal.

In the meantime, the public expects and has a right to receive the best radiation protection we can provide with the resources we have at hand. I have no doubt, but that we can do a better job and that we will, indeed, do a better job as we progress in our Quest for Quality.

Thank you.

DR. MILLER: Thank you, Dr. Peterson, for doing a very capable job of presenting the Surgeon General's remarks. And thank the Surgeon General for us for telling it like it is.

I want to thank both you and Congressman Rogers for coming here to set the tone for what I am sure will be a very productive and instructive meeting.

At this time, it gives me great pleasure to introduce I believe one of the truly great men in the field of radiation control. I know we sometimes confuse fame with greatness, one reason is that we let too many newspaper reporters or TV commentators decide who is to be famous. But I believe greatness is determined on what an individual does. This individual has done a lot in the field of radiation control since he joined the Public Health Service in 1961.

I won't go through his lists of accomplishments since all of you know this individual and what he has contributed. He is one of the most dedicated and determined individuals I know, who understands your problems because he has been on the firing line working with them. -

The Director of the Bureau of Radiological Health, John Villforth.

ACCOMPLISHMENTS AND GOALS: FEDERAL PROGRAM

John C. Villforth[1]

Thank you, Jim. Congressman Rogers and Dr. Brumback, Dr. Peterson, Dr. Moore and Mr. Gerusky: I am very flattered to be here, and when I look out and see you folks with whom we have been working for a long time, I recognize quite clearly this is a cooperative effort. It also gives me considerable pride to stand before you and be able to discuss some of our accomplishments and some of our activities and to suggest where we might place our emphasis in the future.

The title of this symposium, "Quest for Quality" is most appropriate when we consider the increased tasks that are before all of us in the field of radiological health and the limited resources and facilities available to accomplish these tasks. Although quality was always our aim, it becomes a mandatory item as we move to future aspects of radiation protection with limited resources.

The task before us, at times, appears to be insurmountable. Modern technology has developed hundreds of new sources of electronic product radiation that are used beneficially in industry, research, medicine, and the home. There are approximately 5400 plants in the U.S. manufacturing an estimated 30,000 different types of electronic products. The complex electronic product industry with its expansion in terms of the number of manufacturing plants and the variety of products presents a challenge in the immediate future. The growing number of radiation sources which contribute to environmental contamination are increasing the potential for radiation exposure to the public. The combined electrical energy produced by nuclear power plants will increase from 2810 megawatts in 1967 to an estimated 150,000 megawatts in 1980. The potential to public exposure from environmental contaminants includes extraction at the uranium mines and mills, fuel processing, and waste disposal. Every step in the cycle will increase the risk of exposure.

The use of radioactive materials in medicine and industry is also increasing at a rapid rate. For example, the use of radioactive materials in the diagnosis and treatment of disease involved 3,000,000 patients in 1966, and is estimated to involve 7,000,000 patients by 1975.

In addition to the increased utilization and a more diversified number of radiation sources, we are facing the scrutiny of various groups that are challenging our basic standards and criteria. The challenge comes from all segments, the scientists, of whom there are a few outspoken individuals, the conservationists and the private citizens. To a certain extent, these challenges are helpful because they will require us to reexamine our basic criteria and standards and be certain that the radiation protection principles we are operating under are sound. This reexamination should also lead to improved programs for radiation control.

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[1] Director, Bureau of Radiological Health, Public Health Service.

To determine the quality of our efforts let us review some of the accomplishments that have taken place. Since our meeting last year in Montgomery, Alabama, the Bureau of Radiological Health has been delegated the responsibility for the day-to-day implementation of the Radiation Control for Health and Safety Act. This delegation was received on June 4, 1969. A Technical Electronic Products Radiation Safety Standards Committee was appointed in June by the Secretary, Department of Health, Education, and Welfare, and has actually assisted the Department in the promulgation of standards as provided by Public Law 90-602. Many of the activities and accomplishments that have been conducted in the area of electronic products have been done with your cooperation or with your resources, and to summarize these activities may be redundant since we have attempted to keep you informed through our reports and weekly bulletins. However, I feel that it is desirable to review some of these accomplishments so that you can get a more complete picture of the progress in reducing exposure from certain sources.

COLOR TELEVISION

It is appropriate to start off with the review of the color television situation as this was the electronic product which originally caused the public's attention to be directed to the need for more adequate radiation control. The performance standard for television receivers was published in the Federal Register on December 25, 1969, and is applicable to receivers produced after January 15, 1970. The conditions of the standard will become more restrictive on June 1, 1970, and again on June 1, 1971. This standard reflects the comments contained in the October 16, 1969 proposal on television receivers published in the Federal Register where it was concluded that, "...the promulgation of a 0.5 mR/hr limit as a legally enforceable standard with the added requirements that the tests on the receivers be made under the most adverse conditions, that is, maximum rated voltage, maladjustment of user and service controls, and during periods of failure of critical components or circuits, would result in actual emissions substantially lower than the maximum limit allowed by the standard." This standard is both reasonably attainable and technically feasible and we believe will reduce electronic product radiation from television receivers to the lowest level practicable at this time and will protect the public health and safety.

Field surveys to domestic television manufacturer's plants were conducted during the summer and fall of 1969 to determine the x-ray emitting capability of television receivers manufactured after the date of the Act. The field surveys involved the 22 domestic television manufacturers. During these in-plant surveys, 263 color and 89 black and white television sets were surveyed in detail. In addition, 22 color television receivers were selected during the in-plant survey and tested in our laboratory. The receivers were tested for x-ray emission under the various conditions of the performance standard. Although the tests were performed prior to the actual promulgation of the standard, those manufacturers whose sets did not meet the various conditions of the standard were notified so that corrective action could be taken. As a result of this notification, many of the manufacturers replied that changes have been made in their sets that would solve the x-ray problem found in our laboratory evaluations. For example, seven manufacturers have incorporated a high-voltage hold-down circuit in their models which will eliminate surges of high-voltage that could result in x-ray production. Four manufacturers are utilizing a hard glass in the picture tube and one manufacturer is using a lead glass in the funnel of the picture tube assembly. Other manufacturers have incorporated solid state circuitry, have eliminated the shunt regulator tube entirely, or have added shielding to components in the sets. One manufacturer has redesigned the set so that high-voltage controls are inaccessible to even service personnel. Five manufacturers have reported that they are discontinuing the manufacture of a specific chasis because they are unable to meet the condition of the standard.

One of the requirements of the standard is for the manufacturers to provide the Bureau with information on their quality control program which the Bureau is to evaluate. At present, we have received reports from most of the manufacturers and we are studying the quality control methods that they are using in their plant to be sure that receivers produced in the future comply with the performance standard. Labels are also required for television receivers. This means that sets manufactured after the date of the standard will be required to have critical components identified, as well as a statement that the sets comply with the standard. The Bureau of Customs is assisting us in the inspection of imports to see that they are adequately labeled for compliance.

Laboratory tests are being conducted on component parts of television receivers such as shunt regulator tubes and a program for life testing of television receivers is about to be put into operation.

To summarize the activities with regard to television receivers, I think we can be proud of the fact that since the passage of the Radiation Control for Health and Safety Act, we have seen considerable changes by the industry in the design of sets to minimize x-ray emissions. At present, all the new sets that we have tested meet the first phase of this standard. Industry is moving ahead to see that all phases of this standard can be met as soon as possible.

We are also concerned with the 24,000,000 television receivers that are presently in use. To aid in bringing these sets under control, the Division of Electronic Products has recently designed an inexpensive survey meter which can be built by the repairmen for a cost of under $50. A survey is about to be started in the city of Baltimore along with the cooperation of the Maryland Health Department to examine the radiation exposure and the levels of x radiation encountered by TV repairmen. I believe that a final step in the TV problem is one of the continuing education of the repairmen. We plan to work with State and local agencies to develop information which can be used for training or certification courses for TV repairmen.

COLD CATHODE GAS DISCHARGE TUBE

Another electronic product that we have brought under control for the future is the cold cathode gas discharge tube. This problem was first identified by the State health agencies and called to our attention as a possible source of unnecessary x-ray exposure to children in secondary schools using these devices for demonstrations in their science classes. As a result, a survey was conducted, with the cooperation of the municipalities in the States, of 181 secondary schools to more thoroughly identify the extent of the use of these products in schools. Three types of cold cathode gas discharge tubes were found to be emitters of excessive radiation. I'm sure that you are all aware of the field survey report and laboratory survey report on this problem. As a result of this effort, the Bureau of Radiological Health informed the manufacturer that the three tubes in question produced x radiation and advised the manufacturer to stop the production and sale of these tubes. The manufacturer expressed a willingness to incorporate design changes in the tubes. Following these design changes, the tubes were tested and two of the three were found to be able to operate without emitting x radiation. The manufacturer decided to discontinue the manufacture of the third tube. The consequence of this, a performance standard for demonstration type cold cathode gas discharge tubes was published in the Federal Register for comment on January 30, 1970. We expect promulgation in final form very shortly.

MICROWAVE OVEN

Another electronic product causing considerable reaction throughout the industry and concern among health agencies is the microwave oven. We are currently recommending a standard for microwave cooking ovens of 1 mW/cm^2 at the time of manufacture and advising that no product should deteriorate throughout its useful life such that the leakage would exceed 5 mW/cm^2. A sample of microwave cooking ovens has been tested within the laboratory under simulated use conditions. Based upon the results of these tests, it was found that many of the ovens were leaking in excess of recommended standards. In addition, the Bureau cooperated in field surveys initiated by several State agencies. These joint efforts were used to gather data relative to actual operating conditions. Based upon the findings of the surveys and the analysis of the data, the Secretary of DHEW called a meeting of industry representatives and selected an ad hoc committee on microwave ovens to develop an action plan to correct any defective ovens. The plan recommended by the committee provides that the ovens will be located, tested, and a corrective program conducted by the industry. A followup program by the Public Health Service will be conducted to check the validity of these corrections.

Because of the limited availability of near-field survey instrumentation, the Division of Electronic Products has contracted for the development of an instrument for microwave surveys. We have also sponsored research at the National Bureau of Standards facility in Boulder, Colorado, for the development of a microwave measuring device. Under this research, the National Bureau of Standards is fabricating a microwave power density measurement probe which will respond independently of field polarization and energy direction.

In order to provide us with advanced information on prototype microwave ovens under development by industry, the Bureau has an agreement with the Federal Communications Commission to examine ovens that they have under test at the FCC laboratory in Maryland. We have also provided the General Services Administration with radiation safety criteria for microwave ovens for the purpose of incorporation into Federal purchasing specifications.

To date, the response from the microwave industry to the Department's plan for surveying and correcting ovens has been good. Most of the industries have either submitted plans or have requested extensions of time for developing their plan. It is expected that the promulgation of the standard will provide a safe product for the future and the corrective action by industry will reduce the existing problems.

OTHER ELECTRONIC PRODUCT ACTIVITIES

There are other electronic products that the Bureau has become involved in during the course of the year. For example, a laser safety manual has been prepared at our Southwestern Radiological Health Laboratory and a prototype laser survey meter was developed. The diathermy machine, applying microwave energy to humans, has been identified as another potential source of nonionizing radiation exposure to the public. A rather extensive study of the use of diathermy has just been completed with the cooperation of the State of Florida. There is no doubt that the potential for radiation exposure and resultant biological damage exist with these devices.

Projection television receivers were also evaluated during the course of the year, as were a portable x-ray spectrograph and various medical and dental x-ray machines. In all these cases, manufacturers were advised of potential problems and recommendations for use were developed. Activities also continued in particle accelerator and analytical x-ray device safety evaluations. A Conference on Radiation Safety in X-ray Diffraction and Spectroscopy was held in January in Philadelphia. Industry, users, and regulatory agencies were brought together to develop plans for the safe design and use of these devices.

MEDICAL RADIATION

The most important electronic product with regard to population exposure is medical radiation equipment. The Conference on Radiation Control recognized this when they recommended last year that the first priority of a radiation control program should continue to be the reduction of unnecessary exposure in the healing arts. A performance standard for medical and dental x-ray equipment is under development and review at the present time. It is expected, because of the complexity of this type of electronic product, that we will not be able to promulgate a standard before the end of the year. However, our Division of Electronic Products is continuing to evaluate various medical and dental x-ray devices. The reports on these devices have been sent to you. Voluntary industry corrective action has been good. Last year, one manufacturer advised the Bureau that the x-ray tube housings he had manufactured were found to leak radiation in excess of the recommendations in NCRP #33. The manufacturer has worked with the Bureau in developing a timetable to correct this problem and he will advise the State agencies as to the progress of this action.

Inadequate collimation of the x-ray beam still continues to be the primary sources of our concern in the use of medical x-ray machines. As you will remember, following the data obtained in the 1964 X-ray Exposure Study, it was determined that the genetically significant dose from medical radiation could be reduced from 55 to 19 mrads/yr, if the x-ray beam were limited to the area of the film. Several years ago, the Bureau developed and tested a prototype automatic collimating device. Since then, two manufacturers have commercially marketed a similar automatic x-ray collimator and two other manufacturers have advised us of their intent to enter this market. Thus, it would appear that we should move as rapidly as possible to incorporate automatic x-ray collimators into appropriate existing and new equipment. For example, we have recently completed a radiation survey of USPHS hospitals and clinics. Of the 31 hospitals and clinics surveyed, only 63 percent had adjustable collimators available on their x-ray equipment. Recommendations were made for automatic collimation and it is my understanding that nine commercial units are presently installed on equipment in PHS hospitals.

The efforts that many of you have made toward the correction of medical and dental x-ray equipment appear to be reflected in a summary of State surveys soon to be completed by the Division of Medical Radiation Exposure. The results of approximately 34,000 surveys conducted between FY 1961 and 1968 by State agencies indicate that during FY 1963-64, only 40 percent of the machines inspected had collimation that was appropriate for the size of the film used. In FY 1965-66 and FY 1967-68, 49.8 percent and 67.9 percent respectively had collimation that was appropriate. This significant change in a very vital area reflects the efforts of all of you to bring this problem under control. As the Deputy Surgeon General indicated in his previous remarks, during FY 1969, 30 percent of the 108,000 medical x-ray machines in the U.S. were inspected by State agencies. This inspection rate should further reduce the noncompliance in the area of collimation.

We've also completed a review of patterns of diagnostic radiation utilization in 228 selected hospitals in the United States. Data for the study were obtained from those hospitals participating in the professional activity study of the Commission on Professional and Hospital Activities. Data for the years 1963 and 1968 show a marked change in the patterns of chest examination in hospitals. For example, in 1963, 17 percent of the hospital admissions received a photofluorographic examination whereas in 1968 only 9 percent received such an examination. This is contrasted with the increased use of 14" x 17" chest radiographic procedures. In 1963, 17 percent of the admissions received this radiographic procedure, whereas in 1968, 38 percent received this examination. The large film radiographic procedure results in less dose to the patient and greater clinical information than the photofluorographic procedure. Considerable credit goes to State agencies involved in the inspections of such facilities.

Although the equipment aspect of the medical radiation program may be slowly brought under control through the States inspection programs, or following the development of a performance standard, the aspects of technique and judgment associated with medical radiation exposure will require constant attention. The model legislation for users of ionizing radiation in the healing arts, which is in its final draft, will soon go to the Council of State Governments to be included in the Suggested State Regulations. This model was prepared in response to those program areas under Public Law 90-602 which requires the PHS to plan, conduct, coordinate, and support training and operational activities minimizing emission of exposure to people to unnecessary electronic product radiation. This suggested model was designed to increase the technological competence of professional practitioners and their assistants in the use of equipment and material for medical radiation applications.

In support of the general need for upgrading the users of medical radiation, the Division of Medical Radiation Exposure has maintained contracts with the University of Alabama to develop training materials for paramedical personnel in oral Roentgenology, has maintained a contract with the University of California in San Francisco to develop a radiological science training program for medical students, residents in all specialties, physicians, and technologists. We have undertaken an X-ray Science and Engineering project at Oregon State University for undergraduates. This includes the development of course manuals, and evaluation of survey instrumentation and medical x-ray equipment.

The crucial test of the quality of our x-ray activities will be seen in the final results of the X-ray Exposure Study for 1970. This national study based on the same format as the 1964 study will involve visitation to 20,000 households. The same collection and analysis methods employed in 1964 study will be used so that the results of the investigation will be directly comparable. This will afford the opportunity to evaluate the effectiveness of our programs to improve x-ray practice and reduce unnecessary exposure. The 1970 study should also aid in establishing guidelines for future programs.

ENVIRONMENTAL RADIATION AND RADIOACTIVE MATERIALS

Although I have concentrated most of my discussions on electronic products, there is another vital aspect of our activities and that is concern with environmental radiation. The Bureau programs in this area have been designed to assess the degree of radioactive contamination of the environment from nuclear power generating plants, processing plants, and peaceful uses of nuclear devices. This program has provided an independent review of certain of the Atomic Energy Commission's activities. For example, last year, an independent public health evaluation was conducted on 6 nuclear power plants. Evaluations are also being conducted on 15 proposed nuclear power plants and 3 sites. Following these evaluations, conferences will be held with State health department officials on environmental surveillance and other program aspects of nuclear facilities. Bureau studies have shown that radioactive waste discharges from nuclear power generating plants results in minimum radiation exposure to the population. However, good waste management practices are necessary to insure that radiation exposure to the public from these facilities remains low. A comprehensive survey around the Dresden Nuclear Power Plant indicated radioactive iodine-131 as being barely detectable in the gaseous discharge in this type of reactor and that radionuclides could not be detected in milk samples collected in the plant environs despite extensive efforts in the use of extremely sensitive analytical techniques.

The average annual whole body dose received by individuals living near the site boundaries of 10 of the operating power reactors, based on the results obtained from environmental radiation surveillance programs, has been estimated to be generally less than 5 millirems. The results from the study conducted at Dresden indicate the off-site external exposure at this plant may vary between 5 and 50 mR/yr. The results of several of these studies have been published in the last month and are being distributed now. I believe that these documents entitled "Radiological Surveillance Studies at a Boiling Water Nuclear Power Reactor," "Radioactive Waste Discharges to the Environment from Nuclear Power Facilities," and "The Radiation Exposure Overview" will be significant documents to help allay any misunderstanding on the part of the public regarding nuclear facilities. The record built by the nuclear power industry has been good in terms of its environmental pollution control practice, but this is not the time for complacency either with respect to routine or emergency radiation procedures and planning by those responsible for public health and safety.

We are also concerned with the reduction of unproductive radiation from the use of radioactive materials in medicine. For example, a Bureau sponsored survey showed that iodine-131 is the most commonly used isotope in medicine. It is involved in 70 percent of the procedures and accounts for 80 percent of the dose. Therefore, the Bureau's nuclear medicine laboratory at the University of Cincinnati has been responsible for developing a method to reduce the patient dose from this procedure by a factor of 10,000. This involves a more sensitive detecting system and the use of a highly purified iodine-123 as a substitute for iodine-131. Methods have also been developed to prepare low dose radiopharmaceuticals to be used in patient studies for liver, lung, and blood tests.

I have not mentioned the activities of the various offices in the Bureau, the Division of Biological Effects or the Training Institute. These programs have also made significant accomplishments throughout the year and the more detailed investigation of the biological effects, particularly in the newer areas of nonionizing radiation, the establishment of a radiation incident registry to provide an appraisal of incidents of biological injury resulting from the exposure to electronic products, and the completion of such projects as the Cooperative Thyrotoxicosis Followup Study, involving 36,000 patients. The data from this study showed no significant increase in patient risk for leukemia following the administration of therapeutic quantities of iodine-131. Preliminary bio-effects research studies this year have demonstrated that microwaves can induce chromosome abnormalities and alter protein-synthesis. Additional studies will be accomplished to try to determine if congenital malformations result from exposure to microwave radiation.

As we look back over our activities and accomplishments during the year, it becomes apparent that they are the result of the work of many dedicated individuals, both at the Federal and State level, and that only through these combined efforts will we be able to continue to develop and conduct quality programs to protect the public health from harmful exposure and at the same time advance beneficial health uses of ionizing and nonionizing radiation.

GOALS

A presentation of this type is not complete without some mention of the goals of the organization. It might be appropriate to reiterate a statement made by Secretary Robert Finch in March where he established a set of Departmental goals as a guide to HEW program managers in determining specific objectives for FY 1971. Three of these goals are related to the activities of the Bureau of Radiological Health. They are:

(1) "To stimulate efforts to improve consumer protection with emphasis in setting standards, developing sanctions, and certifying safe products;

(2) to strengthen the capacity of the HEW regional offices and State agencies to identify, deliver, and evaluate needed services more effectively and efficiently; and

(3) to exert Federal leadership in producing a cooperative, systematic, and balanced attack on the problems relating to environmental quality."

I believe these goals reflect the concern on the part of the Secretary for those areas in which we have a direct responsiblity.

I think it becomes apparent as I said in the introduction, that the programs that we are conducting must maintain the highest quality and be most productive for the limited resources that are available. It is also apparent to me that the priority established last year at the Alabama meeting of placing emphasis on the unnecessary healing arts x-ray exposure is perhaps as valid or more valid at this time. We have mentioned the magnitude of annual exposure around nuclear facilities, and we have seen that these exposures amount to several percent of natural background radiation in the immediate off-site area. We have also made estimates of the annual exposure to children from color television based on the survey of the 1124 TV sets in the Washington, D.C. metropolitan area. While it must be recognized that this survey is not necessarily representative of the national situation, it does provide us an opportunity to estimate the magnitude of exposure based on the viewing habits and the emissions of the sets as it existed several years ago. The average front-face exposure rate from picture tubes in this survey was 0.043 mR/hr. This results in an annual dose of 1.5 mrem to the male gonads and 0.4 mrem to the female gonads and 3.0 mrem to the eye of children less than 15 years of age. I believe that these doses have and will continue to be reduced as a result of the electronic product control programs at the State and Federal level.

These annual doses must be compared to the present and future radiation doses. The population dose from x rays in the U.S. was estimated for 1964 to be 55 mrad of genetically significant dose. This number has been statistically projected assuming a 6 percent per annum rate of increase in medical radiation. This could result in a genetically significant dose for 1970 of about 95 mrad and about 365 mrad by the year 1990. Depending on the assumptions made regarding the possible changes in health care patterns within the U.S., the results could be significantly increased. Therefore, it is possible that in the years ahead, medical diagnostic x radiation will constitute a population dose that will exceed several times the natural background. This is quite a contrast with the dose equivalent to several percents of natural background that we might be receiving from television receivers or from nuclear facilities. It suggests quite clearly that our emphasis must be to reduce the unnecessary exposure in the healing arts application of radiation. I believe this can be accomplished at the same time enhancing medical use of radiation in diagnosis. I believe that this can be done by improving existing equipment, developing intelligent standards for new equipment and involving all the users in improving their understanding of the applications of radiation. I believe also that the efforts the Bureau has placed in medical systems will help because more careful patient scheduling, more rapid reporting will result in greater diagnostic information available to the clinician and less patient exposure. Also, we must explore new approaches in medical equipment involving such concepts as short-time nanosecond radiography, improved image amplification and television videotape presentations. Such systems conceivably could have the potential for reducing patient exposure by several orders of magnitude.

It is important that all of us understand the relative importance of the various sources of radiation that we are confronted with in order that we might most judiciously use the resources that we have available to us and thereby operate a quality program so that the greatest good can be achieved by all. I hope you share with me the concern for the tremendous task that is ahead of us and that together we can develop a quality program which will be most beneficial to the public which we serve.

DR. MILLER: Thank you, John, for bringing us up to date on the activities, accomplishments, goals and many of the problems that we face.

Our next speaker and our last for the day really doesn't need any introduction to this group. He is Cochairman for this meeting, but I think I ought to say a few words about him.

He is probably the most dedicated and hard working individual that I know on the State level. And I think many of you who don't have day-to-day contact with him may not realize the effort and activity he expends on behalf of looking at the State interests and his dedication and determination that this Conference of Radiation Control Program Directors is going to work and is going to mean something and that the goals that you all have established for yourselves are going to be accomplished.

He is also the only individual I can remember who has been ordered to bed by his doctor because he has been working too hard. And we are very pleased to have him here today.

Tom Gerusky.

ACCOMPLISHMENTS AND GOALS: STATE PROGRAMS

Thomas M. Gerusky[1]

Thank you, Jim. I wish to thank the Public Health Service for the opportunity of again meeting, discussing our problems, suggesting possible solutions, trading experiences, and renewing professional friendships.

The past year has been an eventful one for radiation control on the international, Federal, State, and local levels. We have had our problems, but we also have made a new beginning at a new partnership approach to radiological health.

The approach is indeed a direct result of the passage of Public Law 90-602 and the realization that carrying out the provisions of the law is impossible without the complete cooperation of all radiation control agencies.

During the last meeting of this group in Montgomery, at times discussions turned into gripe sessions, and I believe fortunately so. Both State and Federal programs deserved the criticism. Even so, much constructive effort was derived from that meeting and the months since. A review of the proceedings of the first Federal-State Conference on Radiation Control will verify that fact. This Conference, hopefully, will continue to provide a constructive approach to solving the problem of radiation control nationally.

Let's take a quick look at the past year's highlights from a State viewpoint. You have already heard many times the national point of view. One of the major points made last year was that the top priority of any radiation control program was reduction of population exposure to ionizing radiation, especially from the healing arts uses. Following that line of reasoning, a subcommittee of the Conference met with Federal and industry representatives in Atlanta to set into motion a program to evaluate new x-ray equipment--that is, those items manufactured or assembled after October 18, 1968, the effective date of Public Law 90-602.

After three days of hard work, a report was issued citing steps which should be taken by the Bureau, by industry, and by the State radiation control programs to bring about an effective review and subsequent control of new equipment. The items can be summarized as follows:

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[1] Director, Office of Radiological Health, Pennsylvania Department of Health.

1. The Conference of Program Directors initiate discussions with manufacturers concerning their reporting the installation of new equipment within the States;

2. That each piece of new x-ray equipment be evaluated by a third party for adherence to radiation safety standards;

3. That BRH develop a fact sheet on new equipment for distribution to the States;

4. That BRH notify States concerning any defects under Public Law 90-602;

5. That the States utilize a new reporting form, collect information on newly-installed x-ray equipment, and submit the data to BRH for review and interpretation.

I am sorry to report that very few of these items have been accomplished. The inspection report forms have not been coming in at the anticipated rate. I will take major responsibility for the inaction on the part of the States, including Pennsylvania, for not using the forms. It seems we haven't been finding very many new installations. But, I think effective communications among the States and among ourselves in our own programs appear to be the main culprit. Hopefully, we will be able to discuss this problem later during the Conference and come to some solutions.

But all hasn't been exactly rosy at the Federal and industry levels either. Following the meeting, I twice contacted the Secretary of the X-ray Committee of the National Electrical Manufacturers Association concerning the possible routine reporting of sales and installation of new x-ray equipment with no response. And at the Federal level, we have not received the first page of the manual of x-ray equipment. With effective leadership at both levels of government, this program should begin to roll within the next few months.

Then, there was the high school cold cathode display tube controversy. The Bureau, with the complete cooperation of all States involved, performed inspections and surveys of x-ray emissions from cold cathode display tubes in use in high schools throughout the country. The Bureau found that one manufacturer was supplying the majority of such tubes and that in some instances, with improper high voltage, excessive radiation levels were found in areas some distance from the tubes, thereby exposing both student and teacher to unnecessarily high levels of radiation.

It was obvious that some type of action was needed to redesign the tubes to prevent excessive leakage. But, then, there was again a breakdown of communications. Based upon advice from legal counsel, the Bureau of Radiological Health decided that it must contact each of the high schools in the country to warn them of the potential hazard. But in the process, they forgot to tell the State Radiological Health Programs. They did contact me, and I pleaded for notification of State programs, and that if the high schools must be contacted, they should be contacted through the State educational agencies. This was done. However, in most cases, the State Departments of Education received notification two or three days before the radiological health programs did, leaving a rather frustrating situation for most State program directors. Although many verbal battles ensued, I don't think anyone was really hurt in the process, and I think we both learned a valuable lesson.

On the plus side, appointments of two prominent State program directors were made to the Electronic Product Technical Advisory Committee--Roy Parker from Louisiana and John Heslep from California. Although John has moved up the chain of command in California, there is no question of his dedication and professional ability in radiological health. I commend the Surgeon General on his selections. And, as John has reported, the committee has been working.

And now, microwave ovens. Again, with the assistance of State radiation control programs, the Bureau conducted a survey of microwave ovens in selected locations. We all know of the results of that survey. At least 30 percent were found to leak in excess of the industry's own standard. The Surgeon General called a conference of Federal, State and industry officials to discuss the findings. Hanson Blatz, Jerry Parker, Roy Parker, John Heslep and I were invited to attend. With industry voicing much opposition, a special Surgeon General's task force was appointed to recommend a course of action. Hanson, Jerry and I were again fortunate to be appointed to represent the views of the States. A final document was prepared, and plans are now being formulated by the Bureau to carry out a compliance program, again in cooperation with the States. I am sorry to report that complete cooperation from all manufacturers has not yet been attained, at least to my knowledge. However, in discussing the problem with the Attorney General's office in Pennsylvania, really very little legal action can be taken until standards are published. Again, we are placed in a position similar to other environmental health programs--one of rectifying a problem rather than anticipating and controlling it before it gets out of control. Public Law 90-602 could eventually be very effective in the general area of premarketing clearance for a product which could emit radiation.

Color TV is still rearing its ugly head. By an unfortunate series of episodes in Pennsylvania, I casually informed a local newspaper in a small Pennsylvania that, yes, we were accepting requests upon demand to do TV surveys. Subsequently, three man-months were spent performing such surveys in that city. And we found two sets that were emitting excessive radiation levels. Both had recently been serviced and the high voltage raised to give a brighter picture. Adequate servicing solved the problem.

This is not the way to spend taxpayers' money most effectively. The problem really is being solved at the Federal level. We in the States should be concentrating on the more important areas of radiation control.

One of the major areas, as we all know, and as I previously mentioned, is the healing arts misuse of x-ray equipment. We have gone a long way in correcting the problems of equipment and facility design. But let's face it, very little more can be accomplished until the person who pushes the button to take the picture is adequately trained, whether he be a licensed physician, a chiropractor, a podiatrist, an x-ray technician, a nurse, or a secretary. There must be a national effort to upgrade the standards of education, training, retraining and periodic testing.

And one must recall that the first major effort put forth in this field by a health department was done by New York State with New Jersey and California following their lead. Assistance, advice, and support was given by the Federal Government, but, again, the State governments, where the action is, took the first step. The new California law is unique because it also requires, in addition to the licensing of x-ray technologists, the certification of all individuals, including physicians, who direct the use of ionizing radiation on human beings. No longer will a license to practice medicine be an automatic license to use ionizing radiation as a diagnostic or therapeutic tool.

We, as a Conference, have been involved in assisting the Bureau in drawing up model legislation for a program similar to the one in California. But much more needs to be done. Most of the States are working toward an effective licensing program. The x-ray technicians in the various States are demanding it. As was mentioned in a recent hospital visit I made for an undiagnosed case of the flu, I had the opportunity to meet with the x-ray technologists of a modern hospital. It was a rather informal meeting because I was in my pajamas. And about three hours earlier, they gave me a complete G.I. series. But in two hours of discussion with them, it became very evident that procrastination on the part of the State would not be tolerated very long. They wanted licensing any way they could get it--with or without health department participation.

The phrase that really got to me was, "We're tired of being slaves." We must all act, and we must all act quickly, if proper licensing programs are to be established. I suggest we all consider the problem very seriously and that a continuing committee of the Conference be established to insure that similar programs are established in each State, that reciprocity of licenses be of foremost importance, and that all States be encouraged to adopt this type of legislation.

The environment, its recovery and future protection, is one of the major issues facing America and the world today. Power reactors and the Atomic Energy Commission have been the subject of attack by many professional conversationalists--conservationists and the aroused public.

The Atomic Energy Commission has done a tremendous job, but it does deserve some of the criticism it has received. There is no question that one agency, no matter how hard it tries, cannot completely separate the promotion and regulation of atomic energy. I would strongly urge that Congress take necessary action to place regulatory control in a separate agency, preferably the Bureau of Radiological Health.

I would also suggest that Congress reconstitute the makeup of the Federal Radiation Council so that its only major Federal participants be those agencies concerned with radiation control and that State radiation control program directors be appointed to the Council. It is interesting to note that the law establishing the FRC directs it to "advise the President with respect to radiation matters, including guidance for all Federal agencies in the formulation of radiation standards and"--and this is the important point--"in the establishment and execution of programs of cooperation with the States."

I know of no case where this latter directive has been carried out. As a matter of fact, a couple of years ago, I wrote the FRC requesting a determination be made on consumer product radiation levels, especially in relation to gas contaminated with tritium and other fission products as the result of a plowshare experiment. The reply I received was significantly noncommital.

The States have always had primary responsibility for environmental protection. The new Federal air and water pollution control laws reflect that history. In the atomic energy area, many States have been carrying out this environmental responsibility for a considerable number of years. From personal experience, I know that the Pennsylvania Sanitary Water Board has been issuing permits limiting the discharge of radioactive waste into the streams of the Commonwealth since 1954 when the first commercial power reactor, Shippingport, was announced. That permit, like all permits issued since, restricted the company to release radioactive waste at levels significantly lower than allowed under AEC regulations. Admiral Rickover and the company did not object. The AEC was not happy, but just complained verbally.

The concept recently advocated by the conservationists is that we do not want just a safe environment, but a clean environment. If it is physically possible to reduce pollutants below maximum allowable, why not do so? Someone had to finally test the Atomic Energy Commission's insistence on exclusive control over discharges to the environment. And Minnesota has done just that. Nine States, including Pennsylvania, have joined Minnesota in the legal action. We do not necessarily agree with the individual standards, but we do agree with Minnesota's or any other State's right to set such standards. It is interesting to note the recent proposed amendments to AEC regulations requiring that facilities finally do limit their discharges to the lowest possible level.

The environment is indeed important. The Susquehanna River is a typical example of multiple source discharge on an interstate stream. If Pennsylvania allowed maximum river dilution, Maryland, which also needs reactors on Chesapeake Bay, may have to limit the discharges from its nuclear power plants. Now, let's face it, I am overemphasizing the problem, but who can really tell what may happen 50 years from now with power needs increasing so rapidly?

As an additional problem, the Peach Bottom plant in Pennsylvania is only a few miles above the drinking water intake for the City of Baltimore. Emergency plans for the facility must call for concerted State efforts by both States to prevent a serious problem. Pollution knows no boundaries. We must work together to solve this problem.

As you can see, the year was an interesting one. But I have left out one very important area--our routine programs of x ray, radium, and licensed radioactive materials have been moving along quietly and efficiently.

You know, when I first joined the Pennsylvania Department of Health nine years ago, I really expected to find incompetence at all levels of government, especially in the technical areas. To my surprise and satisfaction, I found in the State Health Departments the complete opposite--a group dedicated, extremely competent, well-educated and hard-working public servants who were attempting to carry out public health or environmental protection programs they really believe in.

In my experiences in radiation control, I have found, again, extreme competence and dedication at the National level, in the Bureau of Radiological Health, the Atomic Energy Commission and the Federal Radiation Council. Over the past two years, since the founding of our new Conference and my personal dealings with each of the State program directors, I am also happy to file the same type of report on them with one major exception.

Added to the list of competency, dedication, hard-working, and intelligence, I must add one more--frustration. On the whole, the State program directors have been unable to do their jobs the way they know they can, not because of major pressure groups like the auto industry resisting efforts to reduce air pollution from automobiles, not because the medical or atomic energy industries are complaining about our efforts at increased radiation safety, not because the public is unconcerned about radiation exposure, but, well, to be honest, that is not the greatest of their worries. It is because we have been unable to convince many of our budget bureaus and legislators of the need for increased funding.

Why? Well, how many people died last year as a direct result of radiation exposure? That's the $5 million question. Can we find one individual and prove that ionizing radiation was the cause of his death? No. But how many still-births, abortions, cancers, leukemias, birth defects, and premature deaths were caused by radiation exposure? Gofman and Tamplin have tried to give us a number. Unfortunately, so has Ernie Sternglass, and so has the grandfather of health physics, Dr. Karl Morgan. They have probably overemphasized the problem, but they tried.

We all know and all believe that we must reduce unnecessary radiation exposure to the lowest possible level. The population at risk is the population of the world. The use and misuse of radiation sources will increase, and we in the States are finding it extremely difficult even to hold the population exposure to its present level.

Let's take a quick look at some of the budget figures. The Atomic Energy Commission's regular appropriation alone this year is $2.359 billion. The cost of the new 200-BEV AEC accelerator is $250 million. The States together, and I am sure the figures are overestimated, spent approximately a total of $7 million during fiscal 1969. Three or four States consumed over 40 percent of that total.

I know of no other program where pressure is being exerted at the Federal level for more State activity where no additional funding accompanies the plea. In environmental protection alone, air pollution control, solid waste disposal and water pollution control, extremely large Federal grants are available. No monies are available to radiological health.

I strongly urge that the Atomic Energy Act be amended now to subsidize on a matching basis those States which enter into agreements and for State environmental monitoring programs and that the Public Health Service budget for fiscal 70-71 include a grant of at least $5 million, again on a direct matching basis for State programs in the area of electronic products. This can be done under Public Law 90-602.

The partnership approach at the national, State and local level is the only way to solve our problem. Federal funding must assist to create this partnership or I am afraid that the problem will never be solved.

Thank you.

DR. MILLER: Thank you, Tom.

I believe there is a saying that goes discretion is the better part of valor, so I will not comment on your presentation, at least at this time.

MR. GERUSKY: You will later.

DR. MILLER: A question and answer period was not planned for this part of the meeting. I would like to adjourn the session until the attitude adjustment period next to the pool.

DR. KINSMAN: One other Department of the Federal Government that hasn't been mentioned is the Department of Commerce. We have a representative of the Bureau of Standards here.

Also, before you adjourn, I would like you to recognize the first and former Director of the Bureau of Radiological Health, Dr. Edwin G. Williams, who recently retired from the Florida Division of Health.

DR. MILLER: I am glad you brought that to my attention. Thank you.

APPROACHES TO THE CONTROL OF ELECTRONIC PRODUCT RADIATION

ADMINISTRATION OF PUBLIC LAW 90-602

Moderator: Roy A. Parker, Ph.D.[1]

DR. PARKER: At this time, it gives me great pleasure to introduce Dr. Bob Elder, the Chief of the Division of Electronic Products of the Bureau of Radiological Health, who will speak on the Activities, Plans and Problems related to Control of Electronic Product Radiation.

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[1] Director, Division of Radiation Control, Louisana Board of Nuclear Energy.

ACTIVITIES, PLANS AND PROBLEMS

Robert L. Elder, Sc.D.[1]

Thank you very much, Mr. Chairman.

It is sort of interesting to give the presentation I have prepared after my superiors higher on the chain said everything yesterday. It puts me in the position of just saying amen and sitting down. For truly, they stole some of the accomplishments that I wanted to relate back to you. In last year's program and report, certain recommendations were made. I believe the division has assisted in getting some of those recommendations into action, even though we accomplished some and we failed in others. I believe it might be a good idea to explain to this group what the Division of Electronic Products has done to support the States.

I think that sometimes people in the States believe we at the Federal level are in a somewhat stronger position than actually we really are. The Division of Electronic Products, which is Mr. Villforth's arm on the technical or enforcement side, represents about 8 percent of the Bureau's budget, and has 10 percent of the Bureau's personnel. If you view it in this perspective, you can see that in terms of supporting you in the compliance areas, you are speaking to roughly 10 percent capability for the Bureau has many mandates beyond that which is expressed in Public Law 90-602. Probably even more importantly, some of the more expensive portions that are required under the law are not our responsibility. Looking at it in these terms, I could explain how the division is organized and indicate the various branches that we have. Representatives are here from each of the branches and can respond to any questions about specifics.

I actually gave up some of the time that I was going to speak so that Mr. Properzio, who is being replaced today by Mr. Valaer, could discuss medical x-ray standards. As was mentioned yesterday by every speaker, this has a high priority, and in the Division of Electronic Products medical x-ray standards, regardless of the TV situation, is essentially our number one priority.

The Division of Electronic Products operates with a budget of about $1.4 million. The $1.4 is very easily divided up into 70 percent for salaries, about 7 percent for contracts (normally in the instrumentation area to develop new concepts or new bases for developing instruments), 15 percent for instruments and supplies, 5 percent for travel and 3 percent for the purchase of products. One can see for a Federal program to operate at a relatively low level, one cannot support the States as the law requires us to do.

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[1] Acting Director, Division of Electronic Products, Bureau of Radiological Health, Public Health Service.

We heard the call for research, but research, in my opinion, is historically funded a lot easier than the monies that are needed to operate on a day-by-day operational basis. I believe that this is the very heart of the matter when we discuss the problems you are facing in the States and those we are facing at the Federal level.

Now, in terms of last year, you gave 12 general recommendations that you thought should be implemented. I thought I would go through these very quickly to indicate what we accomplished on the recommendations, and hopefully solicit from you areas where you think we failed and areas where you think we can improve our situation.

Essentially 50 percent of the Division of Electronic Products' instrumentation budget has been used to purchase instruments for the support of State and local programs. I will come back to this later, on a new program that Dr. Miller and I have agreed upon to support the States. We have obtained 14 signed microwave survey agreements with the States. We have supported two States under special agreements for implementation of Public Law 90-602. We have loaned instruments and calibrated PHS instruments where possible, and we have given a priority in our laboratories to the study of medical x rays. As alluded to by Mr. Villforth yesterday, most of you have received four new reports in the medical x-ray area.

In the control of radiation and Federal installations, there was a fairly specific request that this be done and that HEW take a more active role in making the Federal installations an example situation for the rest of the country. I had a talk with one of your members yesterday, and we recognize that the Federal installations like some State installations, are not examples. However, I think that we have advanced along the road that we must ultimately go if the Federal Government is going to set an example rather than following those set by some of the excellent facilities that exist.

We do have, under a mandate by the Secretary's office, a requirement to survey every microwave oven in HEW. The military has now picked this up, and they are surveying all microwave ovens in military installations. The Navy has specific requirements that this be done in ships at sea. All of these requirements were set following the January 12 meeting that was mentioned yesterday. Also, as a result of our survey of x-ray facilities in Federal prisons, we are working to improve the medical x-ray situation there.

I think that these are the first steps. And surely they are very weak steps, but I believe that we, as a part of the Bureau of Radiological Health, must attempt to put the Federal Government's house in order, in order that it may be an example.

In terms of the States cooperating with standards development, we have tried. This is very difficult because when you are dealing with 50 States, it is difficult to get opinions. But in the medical x-ray area, as Mr. Valaer will attest to, your committee, a committee of your own, was appointed to work with us in the development of the medical x-ray standards.

Now, the procedures that he will go through, I hope will convince you that we are working hard on it. But we believe we are a long way away from good medical x-ray standards. I would be remiss if I didn't tell you there are some real legal problems in writing those standards, and I think Mr. Valaer will bring this out.

The training area is another of your recommendations. DEP does note a specific mandate, but I think that more training is being made available in the new areas of nonionizing radiation than it has in the past. So this is available to your staff.

Also in the area of training, if one can consider publications as a part of this area, we have published five reports in 1970. We have five more reports on a new area of electronic products that should be out to you within a month, and about 12 publications are in process that should be out sometime before January 1, 1971. I could tell you why they are late, but I think everybody knows about the problems of budget and publishing articles.

I think that publications play a major role in meeting the recommendation made by your group. We must take a quick and deep look into the products that are coming out tomorrow and advise you of what you can expect. These publications, which I hope to number about 20 this year, will provide new advice and guidance to you in the area of electronic products.

The eleventh recommendation that was made by the group was in environmental surveillance. We have a serious problem because we have 50 States. Where one State may be capable and willing to do environmental surveillance, another State with another mandate and another priority in their own area might not be so willing. I believe that the environmental surveillance will go to the States as soon as the States want and are willing to accept this particular role.

We do work under a mandate, under a requirement, that we have agreements with States in order that we can fulfill the legal requirements imposed upon us by the law. I mentioned this in the cooperative microwave oven surveys. I think that through this mechanism, we know what you are going to be doing and we know what procedures you are going to be using. Agreements also provide us with a mechanism to get the data, to use the data, and to provide where possible the instrumentations necessary to collect the data.

I think that the last recommendation applicable to my division was relative to the Federal-State implementation workshops. I assure you Dr. Miller is on the phone all the time to me to try for another meeting to discuss problems with States. In fact, I have complained a little bit on the traveling, but we are trying to get to the States to find out which of their problems can be adjusted and incorporated on a 50-State basis to enable everyone to live under somewhat of a uniform code.

I believe a thing that I have heard most since I have been here is in the area of surveillance. Dr. Parker jokingly said to me before, "When are we going to turn compliance over to the States?" Well, this isn't a question I can answer. I would enjoy hearing Mr. Villforth discuss this because in the delegations of authority than come down from the Secretary, they pass down through the chain of command, and each time they say what can be delegated and what can't be delegated. When one reaches Mr. Villforth's delegation, the last sentence in that particular delegation says he cannot redelegate.

When we are talking about compliance, we have to make certain that we understand what the Bureau of Radiological Health can do to work with the States and what legally they have to reserve. I don't believe we have done enough, particilarly in some States that have asked to be more active at no cost to the Federal Government, but there is a limit as to how far we can delegate the compliance activities. I don't believe we have reached that by a long shot.

Now, one of the things I am supposed to talk about today is problem areas. I wanted to spend a little bit of the time today on a specific problem area in which the regional representatives will be very active and of which you will be hearing a lot more. This refers to the regulations called Subpart H, Recordkeeping.

Recordkeeping is a massive document if one looks at it in terms of a regulations, and Mr. Snow will discuss this perhaps more in detail. It imposes upon industry a load for which I think most people have underestimated the expense involved to them and the detail to which they are required to go. Industry is required to submit for review a quality control program for any product for which there is a standard.

Mr. Villforth, through his authority, does not approve of those programs but he can disapprove of them. This means that every industry--and right now we have 27 domestic television industries and 25 foreign--that is 52 quality control programs that will come into the Bureau. These will have to be reviewed against a formal set of criteria. A recommendation will be made by me to Mr. Villforth as to whether he should exercise his right to disapprove of that quality control program. If it is disapproved, they cannot label. To a foreign manufacturer, that means he can't ship into this country.

I think that in terms of Bureau activities, we are going to be swamped in the recordkeeping area. Compliance, as a branch, has six people in it, which includes secretaries. So obviously, we are going to have to call upon the technical staff within the division and perhaps outside the division. I think the burden that we will carry will have to be distributed throughout the Bureau, and I believe this is going to be reflected in less support to the States until we can get over this initial tonnage of paper that we are going to receive.

I would encourage all of you to obtain a copy of these regulations and read them. Some of you have more experience than we do in those areas.

MR. HARRIS: What is the status right now?

DR. ELDER: Mr. Snow will bring you up to date on it, but they should be published next month. There are some problems getting it cleared.

The response by mail was very heavy, but whenever you see these regulations and you find yourself at the close of a day with 15 minutes, and the coffee has already gone and you want to write someone a letter, we would really appreciate receiving your comments and your thoughts on how one might handle or what one should do with the information.

We have tried to eliminate the information that was not needed and because it had no public health significance. To put it into perspective, I mentioned earlier that the budget of the Division of Electronic Products is roughly $1.4 million. One major television industry will spend $1.5 million a year to implement the requirements under recordkeeping. Remember, this was something we were required to do. We had no choice. This is not just a good idea on the part of the Bureau that we are going to require recordkeeping. It is a mandate by law that we do so.

So I would plead with you that when you read these, if you see uses of the information--there are certain proprietary pieces, but that is very small--we would appreciate receiving it.

The regional representatives will be involved in this because there will be followups where quality control programs are inadequate, where we want to make sure that a manufacturer is keeping records. This will be an area where I hope I can enlist the support of all the regions. Also, as to contacting industry in your States, I know you are all sensitive and you will want to know when we do so. We believe that the feedback into the checking on recordkeeping will be a primary responsibility of those people in the field, particularly the regional representatives. And I think that as you talk to them, we hope to get a heavy feedback on how we might be able to implement this.

Now, getting down to the last thing I wanted to mention today, although we have problems in many areas that there may be questions on, I wanted to discuss the instrumentation problem that I think all of us face. If I have heard once, I have heard 20 times since I have been here about the instruments for microwave oven surveys that the Division of Electronic Products bought. This is true. We reprogrammed something in the neighborhood of $30 to $40 thousand, and we have, I think it is 26 or 28 Narda type instruments available for surveys. We have State requests for 108 instruments. Well, obviously, we can't fill these requests. We have loaned instruments to some States and they shudder whenever we say we have to have them back.

Dr. Miller and I have discussed this, and this is pertinent, not only to the Narda type of instrument, but the Stoms instrument for TV surveys, the Victoreen 444 RFC (which is the instrument for television monitoring), as well as other instruments we will be obtaining in the future. It is our intention to take these instruments and put them into what we call a flux pool which will be operated out of Rockville, calibrated and repaired at that facility, and shipped and loaned to the States on a priority basis through the Office of Regional Operations. We believe if we can take a relatively small number of instruments such as the 20 to 30 microwave instruments we have today, put them in a state of flux where, if you and your State are going to be needing one for several weeks, you will contact your regional representative and let him assign them through a priority program based on how many we have and where are the most critical areas that should be surveyed. In this, I think we can keep these instruments in continual use. They will neither be on your shelf nor on ours. It is not our intention to have any instrument collecting dust.

I think by putting this method on a national basis, we can take a relatively small investment and turn it into a situation for maximum use and maximum gain. This program will be developed when Mr. Seabron talks a little bit later with the regional representatives on the microwave oven survey that is getting ready to start.

I am somewhat reluctant to recommend that people, particularly in the States, invest too heavily in the microwave instrumentation area. I know some of you have, and I think that some of you are going to in the future, but I believe this is an area where there is going to be a breakthrough in instrumentation cost. The normal lifetime for any basic measurement instrument is five to six years. We may be two years off on our prediction of a cost reduction, but we are going to see the price come down.

We have a contract with NBS to develop a new type of probe which should be relatively inexpensive. We are developing the electronic package in our own laboratories, and it looks like this one may be a potential instrument that would meet the requirements of the standard as well as the requirements to measure ovens.

We have a contract with IIT Research Institute for which a publication is forthcoming on another type probe that is relatively inexpensive and might be able to be made. The electronic package, again, is being developed in our own facilities which makes it fairly useful.

I am a little cautious to recommend that the States move too rapidly and make heavy expenditures in an area where the price, I believe, is going to come down.

In other areas of instrumentation, I think we can use the flux pool method, as long as all of us realize when an instrument isn't shipped back, you are hurting your neighboring State. Dr. Miller and I have agreed this is the way we can work a program in helping the States in an area where they need help.

As you know, we will also supply the forms and this type of material for your use.

We also request that when you make surveys, we receive copies of the data, and I would like to thank all States that have been involved for the speed and accuracy with which they have sent in the data. Even in the one area where Mr. Gerusky commented yesterday they hadn't been working too hard on new installations, right before I left Rockville, I received a package from one State. So I think that program will also move ahead.

I have tried to be fairly frank with you, to tell you what capabilities we have to help you. I would hope that you would be frank with me and tell me how I can help you better or how you can help me and to constructively point out areas in which we can mutually work together to get the job done at less time and less cost for the overall goal.

Now, I don't maintain that we are running a perfect organization as you don't maintain that you are running one either. But I believe by constructive advice which I often think that you don't sit down and write us about, we can build a better organization within the limited funds we have to develop this law as it should be.

DR. PARKER: Are there any questions?

No comments? Thank you, Bob.

Mr. Don Snow, Director of the Office of Criteria and Standards and who serves the Technical Electronic Products Radiation Safety Standards Committee as its Executive Secretary, will now talk on the Development of Standards and Regulations.

DEVELOPMENT OF STANDARDS AND REGULATIONS

Donald L. Snow[1]

Thank you, Roy. Members and friends of the Conference: The purpose of my being here today is to outline for you the process of developing standards and regulations under the Radiation Control for Health and Safety Act (Public Law 90-602). For your information, the outline essentially is one that we are using also in developing various recommendations or recommended standards which the Bureau must make in carrying out its traditional responsibilities under the Public Health Service Act.

In reviewing the steps we are required to take, I hope to convey to you some of the concern we have for our standards development responsibilities under Public Law 90-602, including the reasons for certain apparent delays in the process. Also, I want to reaffirm that you are, indeed, a very vital part of the standards development procedures.

My comments are largely confined to five topical areas:

The first of these is an outline of the general stages or procedures in this process.

The second describes the evolving role of the Technical Electronic Product Radiation Safety Standards Committee.

The third area is concerned with bringing you up to date with where we stand with respect to the promulgation of standards and regulations.

Fourth, is to review how we believe we have responded to some of the standards-directed recommendations which you made at the Montgomery meeting of your Conference.

Lastly, it is hoped suggestions can be made as to what the Conference and the individual States can do towards contributing to the standards and regulations development process.

Standards Development Procedures

First, under the general stages or procedures involved, is a required step which should be almost self evident, i.e., a review of available guidance and recommendations. No standard that we have worked on so far has evolved out of thin air. Each has found its origin in some recommendation or guide produced by such organizations as the National Council on Radiation Protection and Measurements, or the former USA Standards Institute, now known as the American National Standards Institute. Each of these voluntary standards-setting bodies play an important role in developing what we term criteria.

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[1] Director, Office of Criteria and Standards, Bureau of Radiological Health, Public Health Service.

The next stage in the development of a standard, after available guidance and recommendations have been reviewed, is to develop initial drafts of the proposed standard. This process goes on primarily within the Division of Electronic Products, and under Dr. Elder's direction. It is important to note also there are a number of organizations which are brought into this stage of the standards development process.

In the reviews of the early drafts of the standard, frequent use is made of consultants to the Bureau and, with time, more use will continue to be made of the resources of your Committee on Standards Regulations and Legislation.

Where we find gaps in our knowledge with respect to developing a standard, special studies may be carried out or special meetings may be called, for example, with industry. Such meetings seek to elicit the limitations under which industry is required to operate and any technical considerations which are of critical importance. Following these early stages of developing a standard, a review stage takes place with industry, State and local health agencies, various Federal agencies, such as the National Bureau of Standards, and various professional societies.

In effect, these reviews, sent out over the signature of the Director of the Bureau, start the formalized process of standards development. During and following this review stage, we simultaneously develop what is termed a documentation memorandum. This material, then, consisting both of the memorandum and an advanced draft of the standard, developed in the format of a regulation, is brought to the attention of the Technical Electronic Product Radiation Safety Standards Committee (TEPRSSC) for its advice. The Committee, on consideration of the standard, will then advise the DHEW and, more specifically, the Bureau of Radiological Health on such grounds as whether the standard is reasonable and techncially feasible.

The next stage in the standards development process is one which we might term the first step in the promulgation process, i.e., the securing of approvals and concurrences within our Department. Our administrative superiors must be shown that the standard meets all requirements imposed by Public Law 90-602. On securing these approvals and concurrences, our next step is to publish the proposed standard as a notice of proposed rule making in the Federal Register.

When the comments arrive from industry, other official agencies and professional organizations and private individuals, they are classified in accordance with the particular section in the standard and then analyzed. Where questions of a legal nature are raised, they are referred to our Department's Office of General Counsel.

After further refining of the standard during which process various meetings to clarify specific points may need to be called with segments of the electronics industry, the standard is modified, if necessary, and is published as a notice of rule making in the Federal Register.

The length of time required for this process varies markedly from a period as short as four months to, in some cases, well over a year.

As to certain details of these procedures, I might mention that the most critical step is to make a determination as to what is believed to be the key health effect which is related to radiation emissions from a given electronic product. Beyond this key health effect, we must identify an appropriate health-related criterion. For example, the health related criterion for the television receiver standard is the 0.5 milliroentgen per hour value.

These criteria may originate from a variety of sources. For example, they may be modifications of an original criterion if the criterion was originally based on occupational considerations rather than on the general public. These modifications may precede from first identifying a critical group in the population which may be users of the electronic product or the group most affected by the operation of the product. Modifications will also depend upon the practicability of reducing the absolute value of the criterion. Such considerations as the sensitivity of available instrumentation under conditions of use in the field also play an important role in the final selection of the value of the health-related criterion.

Concurrent with developing the standard, a documentation memorandum is prepared. This memorandum attempts to set down the rationale for the standard, including its scientific basis. It identifies the intended benefiters from the standard and those against whom the standard will be applied. To the extent possible, an attempt is made to outline the general procedures needed to establish that compliance with the standard has been achieved. All key reports and summaries of meetings important to the evolution of the standard are also referenced in this documentation memorandum which serves a variety of needs, including providing necessary background for review action by TEPRSSC.

In the standards development process, we attempt to successively subject drafts of standards to increasingly broader reviews. What we are seeking is to bring a diversity of expert viewpoints into the review process so that neither health reasons nor manufacturing considerations are excluded from any critical stage in the development process.

Role of Technical Electronic Product Radiation Safety Standards Committee

A key phase in developing a standard is its review before the TEPRSCC. This step is carried out by Dr. Elder and his staff.

The operating procedures of the TEPRSSC are still evolving, as I think Dr. Roy Parker and Mr. Lester Rogers, who are here with us today, will agree. However, there is a pattern to its operations. Normally, background materials are sent to the Committee before the meeting where the standards are reviewed. At the meeting, questions are directed by Committee members to BRH personnel or to industry experts. These meetings are open to the public. To the extent that meeting room space is available, anyone may attend.

A record of each meeting is obtained in the form of a transcript. The transcript and other materials submitted for the Committee's consideration at a meeting in connection with each standard are available in the Bureau's docket room.

In addition to these transcripts, summaries are prepared of each meeting, and these are available to any individual or organization on request to the BRH. Copies of the transcripts may be purchased from the public stenographic agency.

The summaries essentially point up the highlights of the meeting and are cross-referenced to certain pages in the transcript.

As mentioned, the Committee reviews the standard for its reasonableness and for its technical feasibility. Since it was originally constituted, the Committee has had to react to proposed standards with unusual promptness. Thanks to the Committee's responsiveness, the BRH has been able to move ahead without delay in its standards-setting activities. I should add that the Chairman of TEPRSSC, Mr. Herbert M. Parker, has been most effective in guiding the group's activities.

Current Status of Standards and Regulations

As regards the current status of standards and regulations which have been or are under development, we can report the following: Subparts B, F, and G of the Regulations under Public Law 90-602 have now been promulgated. Subpart B includes definitions, interpretations and statements of general policy. Subpart F involves notification of defects in and repair or replacement of electronic products.

All performance standards for electronic products will be found in the future under Subpart C and will bear successive section numbers. The whole number, Section 78, will be followed by a decimal number indicative of a specific standard.

For example, the television standard bears the number 78.210. The cold cathode gas discharge tube standard, when promulgated, will bear the number 78.211.

In addition, there are two standards and regulations which have been published as notices of proposed rule making. One of these is Subpart H which is addressed to records and reports required of manufacturers, distributors and dealers. I believe Mr. Saul Harris asked the status of Subpart H.

We can report that Subpart H is moving through the Department for approval and concurrences following which it will be given its second and final publication in the Federal Register. All of the comments received on Subpart H, when first published as a notice of rule making have been analyzed by staff members from the Division of Electronic Products and from the Office of Criteria and Standards. Mr. Marshall Little has been intimately involved with the analysis of these comments for OCS.

MR. HARRIS: Any rough date when it will be finished?

MR. SNOW: Well, as Dr. Elder has said, and I think this is as good a guess as any we have, within a month we should have the Department's clearance of Subpart H. However, because Subpart H places certain reporting requirements on manufacturers, this requires a parallel review and concurrence from the Bureau of the Budget.

This Bureau of the Budget review is going on simultaneously with the Departmental review. And I suspect that the Bureau of the Budget review might possibly take the longer of the two.

The second performance standard, the cold cathode gas discharge tube performance standard, also is within the Department for approval and concurrence.

The microwave oven standard, which will bear the number 78.212 in Subpart C, is also within the Department for approval and concurrence prior to publication as a Notice of Proposed Rule Making.

BRH Response to Standards-Related Recommendations of the Conference

I would like to report on our response to two of your standards-related recommendations made at the Montgomery meeting last year.

The first recommendation appeared in several forms in the proceedings of that meeting. For example, in your meeting summary, constraint number 7 stated that there is insufficient involvement of State programs in development of standards and model regulations.

Also, the first recommendation under the heading of Standards Legislation and Regulations, which I suspect developed from Workshop 10, stated "Federal, State and local agencies should participate in the formulation of regulations, standards and model legislation."

With respect to the above recommendation, we can identify three stages in which you as a Conference and/or you in your capacity as an official of a State health agency can intervene. These are as follows:

First, you can make an input through the Standards, Regulations, and Legislation Committee of your Conference. I believe our system now is firmly established whereby at the very earliest stage of draft development of a standard, this Committee is brought into the review process. Each of you, as individuals, should make known to your Committee your views on those points of importance which you feel should be incorporated in the standard.

The second opportunity occurs when your health agency receives a draft copy of the standard for comment. This step occurs as a somewhat later stage in the development process.

The third opportunity is when you are invited to submit comments on a Notice of Proposed Rule Making which appears in the Federal Register. Our regional radiological health representatives send your agency a copy of the Notice of Proposed Rule Making either prior to or almost simultaneous with its publication in the Federal Register.

Last year Workshop 4 recommended that the BRH establish effective procedures for the development of manufacturers' standards and their implementation and that this activity should be given a high priority.

As to whether our procedures are effective or not, I suspect it is too early to tell. But we do feel that we have taken into account a number of very real and important considerations which you brought to our attention. We have tried to comply with and observe those legal requirements under the Act as well as the administrative procedures for rule making contained in the United States Code.

Conference and State Support in Standards Development

What can·the Conference and the individual States do in support of the standards and regulations development process?

While I think you have done them already, let me point them up again.

First, I would suggest that you continue and expand on the precedent established at the Montgomery meeting to identify specific needs for standards and regulations and attempt to rank these needs in some order of priority.

How should you go about this ranking process? We cannot pretend to advise you, but I suspect you will probably want first to examine the relative exposures of the population from various electronic products for each type of electromagnetic radiation. You will probably consider the present use of a given product and its future potential for growth in use by the population. So we would be most interested, and we would welcome your own notions as to the priorities attached to needed electronic product standards.

Secondly, I would hope that you would see fit to continue and expand the type of work which was started by Workshop 4 on the review of current standards for electronic products. If you recall from the proceedings of that meeting, there were discussed standards with respect to lasers, microwaves and ionizing radiation from electronic products. We certainly welcome your views on these matters.

Third and last, with respect to "going on record" for a specific standard, we cannot say enough for the written record on the development of a standard and, particularly, how you view that standard. I think it is normal and certainly the mail reflects that the comments we usually receive are those which are adverse to various aspects of a standard. If you agree with the standard, we would like to have that information also because, in the final analysis, we can only react to how you collectively feel. And if the record is all concerned with things which should be changed, then, of course, we are going to try to accommodate to those comments to the extent that we can. However, if there is somewhat of a balance of preponderance in favor of the standard as published, we would like to know that, too. And this is highly essential as far as building the record in the event of a future court case involving that standard.

This is all, Mr. Chairman. I would welcome any questions.

DR. PARKER: Questions, comments?

MR. HARRIS: Saul Harris, Region II. On this recordkeeping thing, Bob Elder points out there is going to be a ton or more of paperwork coming out as soon as the recordkeeping proposal is developed and accepted. I would imagine the ton or more is going to be proportioned by States, or at least by regions to begin with and then by States, depending upon, say, the industrial population. Am I correct in that assumption?

DR. ELDER: No. First of all, I think this is a little difficult. One of our problems here is really knowing something about what we are going to get. I believe that this is something where Mr. Snow said that they were feeling their way in setting up the procedures under which the Committee is working. I can assure you we are feeling our way under this one also.

I alluded to the records in that they contain proprietary information will be held in Washington and worked out on a manufacturer-by-manufacturer basis. We cannot collectively discuss two industries at the same time or two manufacturers at the same time. It is always one specific manufacturer.

For example, say we would get in a recordkeeping system for a given manufacturer in New York and this manufacturer indicated that he was doing certain things for a particular type of equipment and his submittal was weak in terms of what he said, but it looked pretty good overall. Well, the Director can elect, with cause, to take a look and see if he is really doing it, because most of the manufacturer's records will be maintained in his own shop, and he will tell us what he is doing.

Now, if we think there should be more or someone else thinks there should be more, then we can request more and perhaps we can indicate that some of them aren't needed.

Now, it is at the time that we have to go in and look to see if the manufacturer is really keeping records that I see where regional people will become involved.

MR. HARRIS: How about the State people?

DR. ELDER: I think it is a little premature. First of all, I am sort of worried as to how much support the States can give in this area. I differ somewhat in my personal opinion. We have roughly 17 AEC Agreement States. This is an area where the States can move to take over. The number may be wrong, but less than 50 percent of all the States have moved to take over this legal activity. So I am not certain that all States would want to have an active role in this capacity if we had a mechanism.

MR. HARRIS: But they are going to get telephone calls from people regardless of whether they have a role which they will have to answer as the Federal Register comes out with a publication.

We also ought to discuss distributors because distributors are part of the recordkeeping system, right?

DR. ELDER: Well, we are getting in some of the details. The distributors can keep records unless there is a certain election on the part of the actual sales organization. But, again, I think it is premature to really go into the details until we see something about the response. I am of the personal opinion that with a 6-man compliance office that is going to have to set up the recommendations by which recordkeeping is going, that it will be a long time before we can get the information out to what I consider the second stage of spreading the work load. And that is to the regional representatives.

I believe that we really can't go into how we are going to do it until we see something more about what we are going to get. I am convinced that half of the manufacturers that are required to keep records don't even know it.

For example, in the microwave oven survey, we have received valid criticism that we haven't transmitted information to the regions and States. And this is absolutely valid. But, unfortunately, we haven't received the information from the manufacturer. We can't transmit what we don't have!

Now, at this meeting, I think you know that we are prepared to discuss a half dozen of the manufacturers' programs.

I think this is what we are going to be faced with in recordkeeping. It is going to be an individual manufacturer-by-manufacturer basis. And I know that we can swamp New York, Chicago, California, very easily.

MR. HARRIS: We know it, too.

DR. KINSMAN: No, you can't swamp California.

DR. ELDER: I forgot that one of the programs in California is one-half the size of the division, and I think they have more money. But, what I am asking here is for a little patience. I think the burden is also on Mr. Britain who is in charge of this responsibility to make sure the information gets out to you people as to how we are progressing.

MR. HARRIS: It will be before the next meeting of this Conference, and, therefore, it may want to discuss it as we are doing now.

DR. ELDER: Dr. Miller may want a whole day on recordkeeping next year, because without the help of the regions and States, we are going to bog down. With 35,000 manufacturers, if one said that 10 percent of them were going to submit a document to us, that is a lot to start with--and we have a 6-man compliance office. I think 35,000 would be involved and I think that is an underestimate because that does not include foreign manufacturers.

MR. HARRIS: Or distributors.

DR. ELDER: Well, the law is specific for manufacturers. Distributors are not spelled out in the definition of the law.

DR. PARKER: Further comments or questions?

Thank you, Don.

Mr. Peter Valaer of the Division of Electronic Products will substitute for Mr. William Properzio. His topic is X-ray Performance Standards.

X-RAY PERFORMANCE STANDARDS

Peter J. Valaer[1]

Speaking for Bill Properzio, I would like to talk to you about what we have done so far with respect to the performance standards for diagnostic x-ray equipment and what kind of a document we have at this time.

I was assigned to the Division of Electronic Products in September. And at that time, the x-ray lab under the direction of Sid Heidersdorf had just completed its first draft of this standard. They called it draft number one. This caused some confusion because there were already three drafts before that which were prepared in the Division of Medical Radiation Exposure.

Where we stand now is that we have prepared two drafts in the Division of Electronic Products that have been reviewed in-house. That is, within the Bureau of Radiological Health. And following those two reviews, we prepared a third draft which was sent to a panel of six consultants. Of these six men, four had served on NCRP committees, and one of them had been an advisor to one of the NCRP committees.

We also sent the draft to a committee of this group of you people under the chairmanship of Hanson Blatz, who, unfortunately, was out of the country at the time. And so that committee has not yet been heard from.

Following the reviews of the consultants, we prepared another draft which we have just gotten out on the 17th of this month. And again, this draft has been sent to the consultants and again to your committee.

I would like to tell you something about what this draft is like and anything I say about it is subject to change because we still have a long way to go in its development process.

First of all, we have tried to follow the NCRP as much as possible, as much as we think it is practical for this type of document.

We have also borrowed occasionally from other documents such as the ICRP and the International Electro-Technical Commission. Where some point was not adequately covered, say in Report 33, we had to borrow from another document. We can't follow the NCRP too closely for several reasons.

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[1] Chief, Engineering Development Section, X-ray Exposure Control Laboratory, Division of Electronic Products, Bureau of Radiological Health, Public Health Service.

In the first place, our law has specified that we have to write performance standards. In some cases we can take a paragraph or so out of the NCRP, just lift it verbatim. And it is a performance standard. For example, the matter of tube housing leakage. This is the way it is written in the NCRP Report 33. It is a performance standard, and we can lift that just as is. In other cases, we have to do some rewording. For example, the matter of filtration. In a performance standard, we can't say that you have to have 2.5 millimeters of aluminum. But we can say that at a certain kilovoltage, the half-value layer has to be so and so. That's how we get around that.

Another difference arises from the fact that the NCRP standards are actually recommendations, and they are not mandatory in the sense that they have any legal status. If the NCRP says a certain thing should be done, we either have to take that "should" and change it to a "shall" or we have to drop the matter completely. It just doesn't mean anything in one of our standards to say something "should" be done.

Take the business about the entrance exposure rate in fluoroscopy. The NCRP says it shall not "normally" exceed 10 R/min. How can you put that in a performance standard? In some respects, we have gone beyond the NCRP. We have specified that the equipment has to meet certain standards of reproducibility. This is an area that the NCRP has not yet gotten into.

Then there are some appreciable problems which are beyond the scope of our draft and probably beyond the scope of Public Law 90-602 as we interpret it. These are the installation of equipment, the use, maintenance, any equipment made before the standards became effective, and component systems. All these can be controlled at the State or local level even though they don't come under the standard.

This matter of component systems is especially sticky as it could be a means of evading the standard. It is common practice especially in hospitals to replace components on a piecemeal basis. Say, one year they will have a 300 mA generator, and they will decide to get a 500 or 800 mA generator. The following year, they said they want a ceiling-mounted tube stand instead of a birail tube stand. Maybe a couple of years later they get a new table or a new image intensifier or something like that. They just add these pieces on as they get the money and as the need arises. Each of these components can meet the applicable requirements of our standard individually--that is, those requirements which apply to that particular component. But it is possible that in acquiring components like this, the ultimate system will have something missing.

For instance, we would like very much to require automatic collimators, but building up a system componentwise, you could end up with a system with no collimator at all. Each component would meet its own requirement as it was purchased, but the combination of those wouldn't meet the standard for a whole, complete unit.

Bob Elder mentioned a legal problem that had come up. I hadn't intended to bring this up because we don't have the answer to it. But we have asked the General Counsel for an opinion as to whether the Public Law 90-602 applies to individual components. I personally think it can be made to apply, but we have sent an inquiry to the General Counsel for an opinion on that.

Well, as you see from the number of items that we cannot cover in a standard that we aren't going to put any radiological health programs out of work. There is still a lot that has to be done right at the local level just plugging loopholes.

The next step in the development of these standards is a meeting that is going to be held in Rockville next week. We are getting our consultants together to iron out some of our differences. Hopefully there will be a representative from this group present at that meeting.

Following that meeting, a revised draft will be sent out to representative groups such as the American College of Radiology, the American Dental Association, the NEMA, the manufacturers group, Federal agencies, of course, you people, any other groups that may be interested. We don't have a mailing list at the present time, but the draft would be available to anyone that asked for it.

I won't go into any further detail of what our schedule is from there on. If everything goes well, we could have the standards by January 1971. It could be, on the other hand, that difficulties would arise causing it to be later than that.

DR. PARKER: Thank you, Pete.

Any comments or questions?

MR. SHAVER: John Shaver, North Carolina Board of Health.

Would you speak to the impact that the performance standard might have on State regulations?

MR. VALAER: There is a section in the law that is called Section 360(f). Does someone have it?

Section 360(f) states whenever any standard prescribed pursuant to Section 358 with respect to an aspect of performance of an electronic product is in effect, no State or political subdivision of a State shall have any authority either to establish or to continue in effect any standard which is applicable to the same aspect of performance of such product which is not identical to the Federal standard.

I would say this is a rather considerable impact. It may effectively wipe out--

MR. SHAVER: Would this rescind some of our existing regulations, then?

MR. VALAER: I am not a lawyer, but as I understand it, I think it would.

MR. SHAVER: What type of plans are being formulated for this transition?

MR. VALAER: I don't know.

MR. HARRIS: Who is going to inspect against it?

DR. ELDER: I think, John, it is a very good question and it also looks like an area where we are getting ready to fight. I think that is a very good question and I think this is one of the purposes of this meeting.

I believe that where there are specific problems, where there are conflicts in this area, we have to work those out on a case-by-case basis. The first draft of the standards and the very early draft was sent to the States, and whenever these standards hurt each individual State, they should be viewed in the light that this is a problem area.

This is the reason I have, with Mr. Villforth's concurrence, not rushed these standards. And this is an area where we want valid comment. If we are going to run up against you, and you have a better standard, then we have to look at it and accept your words.

I would ask Dr. Parker if I could mention one other point that I think should be reviewed for this group. When Mr. Snow and I sit down to write a standard on any matter, particularly medical x rays, we are required both historically and by administrative practice to review the legislative history of the law itself. There is a dialogue between one of the Senators, and a very well known leader in the cause of the consumer, which appeared in some verbiage in the Committee reports about who would enforce medical x-ray standards and the problems of enforcement. I would encourage everyone to look this up in the Senate hearings and read it because it is the consensus of that particular dialogue, as we interpret it, that the States will have a primary role in this area of site inspection over that of the Federal Government.

So, obviously, if this is the concept of Congress, the indication that we received, then we have to go along with it. I believe that we can do this if, whenever we send these standards out to you, you realize that there are real headaches and problems, not only for you, but for us. As Mr. Snow said, the record has to show where you agree with us and where you do not agree with us.

In fact, I wrote down Mr. Snow's words which I think are something we should always remember: "Let the record show when you agree with us and let's iron out whenever you don't agree with us."..and I believe we can do this.

On several occasions I have talked about specific State programs where we are looking at what we are doing versus what they are accomplishing. It is somewhat surprising that the differences are very minor when you get right down to the details of it. Most of the differences are reflected in the different type of authority we have over what you have. I am not familiar with each State, but some States do have the right to establish almost design standards, where we are limited to performance standards. I believe in cases like this, we may go to the lawyers and say, "Does this performance standard interfere, supersede, a design standard or more restrictive standard of the States?" I believe it will boil down to this. I certainly want to leave this Conference with the full understanding and under the direction, very frankly, that I have from Mr. Villforth that we will iron these out. I hope every State takes it very seriously when they see the document because we have very heavy pressure upon us by the Department as well as outside groups to promulgate these standards. I think that our role, our stand, in not rushing is indicative of the very fact that we want to eliminate a lot of problems.

I hope everyone will take it as seriously as Mr. Valaer has in reviewing and commenting on the problems that these standards are going to give the specific States. I would indicate to you that we are having little or no disagreement with this mechanism. Industry is anxious for these standards, so I think they will give us very constructive criticism. I believe in this particular standard, we are talking about 95 percent of the population exposure.

DR. PARKER: Thank you, Bob.

Let me exercise a minute of personal privilege here. I do think that the manufacturing standards will necessitate giving up on the part of most of us States a little of our individual prerogatives. I don't think this is bad. Place yourselves in the position of the manufacturer. If we have 50 different standards, the manufacturer is still going to have to manufacture his equipment according to the most strict of those standards. So, I think that we are all going to have to agree. And we shouldn't have that much trouble agreeing on a nationwide manufacturing standard.

I think this leaves us in the States a lot of prerogatives for individual interpretation of the use of the equipment. We still have a big area here. But there shouldn't be any real problem even though we have to give up a little of our initiative and prerogatives by agreeing on one set of manufacturing standards.

Hanson, I believe you had a question.

PROFESSOR BLATZ: Has the problem of establishing the date of manufacture been resolved? If you will recall, those of you who are on the Committee, they devoted quite a bit of time to that because it is not easy to establish the date of manufacture, particularly of the many installations that are made up of components assembled at the place of use.

MR. VALAER: I believe that Public Law 90-602 does require labeling which includes among other things the date of manufacture. It includes the name of the manufacturer, the address and the date. I believe the law says that the date can be put in some kind of code which, however, will have to have a key in our possession so that if they meet that requirement, that labeling requirement, we would be able to know the date of manufacture.

PROFESSOR BLATZ: But this raises the problem, then, of an installation that is made up of many components assembled at a place where it is going to be used. This is the same question you were talking about before. What is considered the date of manufacture of a combination of several components?

MR. VALAER: Of each component?

Well, I don't know what to do about that problem.

PROFESSOR BLATZ: Most of them are made that way.

MR. VALAER: I know they are. I think the only thing we can do is to require each of the major components to be dated. I don't know how else we can cope with that. It might be obvious at this point that Public Law 90-602 was largely oriented to consumer products, such things as TV and microwave ovens, where this component problem doesn't exist. But in x-ray equipment where you put together little boxes like a stereo set, you are going to have to identify each component. And each component is going to have to meet the requirements for that component.

PROFESSOR BLATZ: But then the user may choose not to buy collimators.

MR. VALAER: I don't know what to do about it. That is one of the things that has to be handled locally. I just don't see how we can do it in a code directed toward the manufacturer.

MR. HARRIS: How can Washington then handle this question? Really, it is the local assembly plant that makes the final decision on dates.

MR. VALAER: I think Bob might have an answer to that.

DR. ELDER: No, I don't have an answer. But maybe I can show you what we are trying to do in it.

We recognize that the component problem is one that has some legal terminology; that it is a little bit insufficient in terms of being able to go in and state labeling requirements and dating what is the total package. We know that the standards are quite applicable to mobile x-ray machines, package units, and there is no problem. We could put in the date of manufacture, and it would be quite easy.

In the packaged units that are made up of pieces, the essential question is, if you add a component to your system, does the total system then have to meet the total requirement?

Now, this is a legal question that I think we are just going to have to get answered.

Now, as you know, in the putting of a new tube into an x-ray housing, you have got a new tube, and the definition that now applies--is this a retrofit or is this a new product? I hope that through Dr. Miller's office and through the Committee's assistance we will get some guidance in this area. I think we have to recognize we have existed 75 years without enforceable medical x-ray standards at the Federal level. I expect it is going to be a good number of more years until we satisfy all these problems.

MR. VAN FAROWE: Don VanFarowe from Michigan.

In which court does the State enforce Federal regulations?

DR. ELDER: The law is specific that cases tried under the Federal jurisdiction are in a Federal court. This is normally always spelled out by law of where the trial will be held. This is if you are acting under a Federal authority, under the Public Law 90-602, rather than your own authorities.

DR. PARKER: Further questions?

One other point of consideration might be that those of you in the position now of having to reprint your regulations may resist a little bit more Commission pressure to stave off a reprinting until the x-ray standards have been maybe formulated. Realize, of course, the Commission is coming out with some fairly significant changes in Part 20 and after. But remember your x-ray standards are going to be 20, 30, maybe 40 percent of your total regulations. So this is another point of consideration.

Any further questions?

If not, thank you.

APPROACHES TO THE CONTROL OF ELECTRONIC PRODUCT RADIATION (continued)

ADMINISTRATION OF PUBLIC LAW 90-602

Moderator: Simon Kinsman, Ph.D.[1]

DR. KINSMAN: I appreciate Dr. Parker's introduction of this particular session. And to show you that it isn't all jokes, I would like to clarify some of the things that went on in Dr. Parker's session. One of the things in particular was the last question that was asked. If you have to take a case to court, where do you take it?

If any of you have State regulations, it is administrative law that you are acting under. And if you want to prosecute, then you will prosecute in the State court. If you are working as an agent of the Federal Government, as Public Law 90-602 says, then you can be established as an agent of the Federal Government. If you are doing inspection or work of that kind as an agent of the Federal Government, then your court proceedings would take place in Federal court.

Is that clear? I thought you would like it. With States righters, we don't like to have to take it to a Federal court. In fact, we like to work it on a district attorney's office level. He can generally bring it to a conclusion faster than the State Attorney General's office can.

Now, before opening this up, I would like to say that this session is not confined to Public Law 90-602, not to the new x-ray equipment. This takes in the whole gamut of x-ray legislation, inspection and anything else pertinent to it. And as you can see and as heard yesterday, the x-ray program is the number one program for the Bureau of Radiological Health.

And when I say Bureau of Radiological Health, that is the designation of the California organization. It happens to be that the Federal Government adopted that a few years later. But I think New York, likewise, has a Bureau of Radiological Health. Anyway, we want to cover the entire gamut. We have an excellent panel.

Without further ado, we would like to hear from a State on the experience of establishment of inspection priorities by Mr. Richard M. Fry, Kentucky State Department of Health.

Mr. Fry.

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[1] Chief, Bureau of Radiological Health, California State Department of Public Health.

ESTABLISHMENT OF INSPECTION PRIORITIES

Richard M. Fry[1]

I am reporting to you on a priority system for the inspection of x-ray facilities that was developed in our radiological health program. Its principal authors are Bobby L. Dillard and Charles M. Hardin.

In 1961, Kentucky realized the need for x-ray surveying, but we were somewhat at a loss as to where to start and what to do. So the initial system set up for inspecting x-ray facilities was based on geographic area.

To conserve travel monies, we worked by land areas starting in the western part of the State and working back toward the center. This worked very well for us. We would say that this was the way we preferred to start. But we soon realized that it was necessary that some kind of priority system be established based on facilities rather than just on location.

It has been brought out today and yesterday that medical and dental x rays are the largest contributor to the unnecessary exposure of the population from man-made sources. It is the primary objective of a radiation control program to reduce this unnecessary exposure to the lowest practical level without hindering the beneficial uses of such a valuable tool.

Since the immediate impact of reducing radiation exposure to the population is not readily apparent, it is necessary to evaluate this impact by some other means that is not directly visible. State radiological health programs are constantly faced with the problem of evaluating the effectiveness of their programs in improving the health of the population by their particular service.

Any method or system that a program uses to perform the evaluation of its effectiveness consists of three distinct processes:

1. A method of evaluation based on the need for the specific service must provide for established priorities, with the benefit of such services being the maximum for each dollar that was spent.

2. The method should provide a mechanism to guide the program to reach its objective.

3. The method must show that the activities performed by the program are based on the greatest need for the greatest number of people.

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[1] Director, Radiological Health Program, Kentucky State Department of Health.

In the fall of 1968, the Kentucky Radiological Health Program initiated a system of establishing priorities for performing x-ray inspections throughout the State. This system provided us with a method of evaluating our effectiveness in accomplishing the objectives of our program in reducing x-ray exposure to the population. It is felt that this system if used in Kentucky can be adopted and/or adapted for use in other States as well.

Over the years, a number of systems have been used to establish frequency of x-ray inspections. However, none of these methods seem to effectively combine deficient items found during past inspections with the total number of people exposed together to determine the frequency of an inspection. Since the major objective of a radiation control program is to offer its service to the maximum number of people, the system developed combines both of these factors--that is, the deficiency of the machine, and the numbers of people involved--and thus establish a facility priority number.

In certain instances, there may be geographic, economical, occupational or other conditions that require special attention. Although the population affected may be small, the potential problem may be great. Under such unusual circumstances, it would be necessary to deviate, or actually ignore, the priority number that would be established under such a system.

This system does not provide a priority number for therapeutic, industrial or veterinarian systems. We limited it to the medical diagnostic, dental and chiropractic facilities because they are more alike. The type of activity under therapeutic, industrial, and veterinary operations are drastically different. It is not impossible to establish a similar system, but we just did not have the time or the input to evaluate a system in a therapeutic facility, for example, where you are intentionally exposing a patient to doses that are entirely different than radiographic procedures.

To arrive at the appropriate facility priority number, each machine in a given facility is handled individually, then debit points are assigned, and from here on keep in mind the higher the priority number, the higher the points, the worse the facility. It is the reverse of the grade. If you keep this in mind, maybe you can follow along.

But debit points are assigned for deficiencies that are noted in radiographic, fluoroscopic and dental x-ray machines. These debit points were determined by weighing the items against each other as to their importance in reducing unnecessary radiation exposure. In these cases, both the operator and the patients were considered. And the particular debit numbers represent the emphasis you wish to place on a given facet of your control program.

The initial system that we have set up places, for example, under radiographic machine a 50 point debit weight for matters that deal with filtration and collimation. That is, 50 points out of a possible 100 debit points that a radiographic machine could obtain. (See Table 1.)

The breakdown is that there are 12 points taken off for various deficiencies in operating personnel, 6 points in things dealing with the film and the screen, a total of 6 points on the weight to the darkroom. As we mentioned, 50 point weight to filtration and collimation. You can see there the importance that is placed on this particular aspect. Four points were weighted to the timer. And then there were 22 points weighted against various matters dealing with protective devices. The specific individual number breakdown is given in the table and also will be published in Radiological Health Data and Reports.

On the fluoroscopic machine, the distribution is entirely different. I will only pick out one or two to use as examples. The weight here deals with 22 points out of 83 possible debit points dealing with the fluoroscopic screen. It is ganging, shutters, lead glass, various aspects of it, and deals then with a number of other breakdown points--with operating personnel, equipment, shielding, dark adaptation, particular procedures being used, the output of the unit, filtration, timer condition and the overall condition of the fluoroscopic room. (See Table 2.)

A similar breakdown with different weighting has been placed on the dental machine. (See Table 3.) Again, with the dental unit, the heavy weighting is to filtration and collimation. At a later stage in your operations when you would say, "Well, I have cured the filtration and collimation problem," you could change the weighting altogether to place the emphasis on another aspect.

If you were dealing in an area where you felt specifically concerned about matters of judgment, techniques, then you could change the weighting system to come up with the various debit points that could be assigned against a given machine. The debit points given for each item are only considered if the machine does not have or use the item that is in question.

The data obtained from past inspections are evaluated and assigned debit points out of the data just given. It is important to emphasize again that the debit points are only assigned when the machine or facility does not meet certain criteria in question. If that machine meets the criteria, no points are assigned.

After the debit points are assigned, they are totaled for each machine. This total is then multiplied by the total radiographic or dental exposures made per week for the machine in question.

For fluoroscopic machines, an additional factor of 10 is used to correlate the differences in small milliampere seconds used for radiographic exams compared with large milliampere seconds used for fluoroscopic exams.

The product obtained by the multiplication of the debit points and the exposures per week with the additional factor of 10 for fluoroscopic machines may be large and cumbersome. Therefore, this product is divided by 100.

Radiographic & Dental Formula:

$$\text{Priority Number} = \frac{\text{Total Debit Points x Exposures per Week}}{100}$$

Fluoroscopic Formula:

$$\text{Priority Number} = \frac{\text{Total Debit Points x Examinations per Week x 10}}{100}$$

The priority number obtained above represents a number for a specific machine. If the facility has only one machine, this number also represents the facility priority number. When the facility has more than one machine, each machine priority number is added, and the total obtained is used as the facility priority number.

Facilities with high priority numbers can then be grouped together. X-ray inspections are performed, giving preference to these particular high priority facilities. Since this system combines the deficient items with the number of people exposed, it is felt that this priority system serves as a method to assure that the greatest number of people receives the service of the program and what it offers and that the benefit of this service will be maximized for each dollar spent.

In regard to evaluating the effectiveness of a radiation control program, the priority system can also serve as an excellent "measuring stick." We can show graphically the distribution of facility priority numbers for dentists, physicians, hospitals and chiropractors.

Such tabulation shows that certain disciplines may generally fall into specific priority groups, but an important point to observe is that there are some individual facilities in each of the groups that have very high priority numbers. Therefore, this system indicates that inspection frequencies cannot be established on disciplines as a group but must be evaluated on the merits of each specific facility, regardless of the group that the facility is in.

The success and effectiveness of the program in meeting its objective can now be measured by a comparison of priority numbers from one year to the next. A reduction in the overall priority numbers and their distribution is a direct indication or measure of reducing unnecessary x-ray exposure to the population and can actually be quantitatively and numerically assigned.

It is thus felt that the Priority Number System has successfully given one method of evaluating the service offered by a radiation control program.

This system does make it necessary that you have an initial inspection. You have got to have the basic information on the facility before you can assign such a priority. So you must have a first round of surveys before you can start,such a system. But from there on you can put your greatest amount of effort on your greatest problems.

We have been concerned for some time that various States and groups would pick a particular discipline and say, "This is my problem area," or a particular group of machines and say, "These are my busy machines and that is my problem area." This gives us the opportunity to correlate two or three different factors to come up with priority numbers.

With this system, you could have just had two machines and one of them would be assigned the lowest priority number. They would be your best and your worst machine. And no matter how good that one machine was, it is still your worst machine. That is where you should spend your effort.

Questions?

MR. HALPERIN: Jerome Halperin, Chicago.

Mel, this system makes no effort, on face value, to account for the possible genetic or gonadal exposure of the procedure being performed by this machine. In terms of the public health importance of an x-ray control program, would it not be preferable to try to include another factor to account for the gonadal exposure of the procedures for which this machine is used most? For example, a cystoscopy machine would certainly represent a higher priority than a normal radiographic machine, yet under this system, it would have the same priority number.

MR. FRY: See, I told you this system could be modified! This is very true. In light of the emphasis on genetic exposure significance, this suggested modification may be very meaningful. Many of our States get concerned with compliance and say, "These are the regulations; we must obtain compliance with them." Most of the items that you will see throughout the presentation are matters that would deal with compliance under a set of regulations.

Ted Britton from Georgia Department of Health.

MR. BRITTON: How do you handle the situation such as an overhead tube that may be used as an overhead tube and as a fluoroscopic tube and say it is defective in filtration? How do you handle it? How do you weight it? Do you handle it as an overhead tube and then a fluoroscopic and combine it?

MR. FRY: A single tube or two-tube combination unit would be counted twice and would have a radiographic priority number and would have a fluoroscopic priority number.

MR. BRITTON: And you report them as a combination of number?

MR. FRY: They would be added together just as if they had two machines.

MR. FRANKEL: Bob Frankel, BRH, New York.

Do you include therapy under radiographic units?

MR. FRY: No, sir.

MR. FRANKEL: What do you do in the case of a therapy unit?

MR. FRY: The therapy, veterinary and industrial units are not covered in this system. They represent in Kentucky, I think less than five percent of our total machines. We just add them in when we are working in a given area.

Bill Graham from Tennessee.

MR. GRAHAM: Do you require compliance with your regulations?

MR. FRY: Of course...and that is handled separately.

MR. GRAHAM: I was just wondering if you do require compliance and if they report compliance, how do you establish a priority number?

MR. FRY: The priority number is based on the facilities surveyed. Let's say collimation is out and they need additional collimation. They send us a post card saying, "We now have additional collimation," that does not change their priority number.

In addition to this priority number, we still have a compliance file. The radiation user has a 60-day compliance period and there is still that regular compliance follow-up to assure compliance with the regulations.

But a number of these things have to deal with matters that are not covered by regulations but still contribute to the radiation exposure involved.

Marshall Little.

MR. LITTLE: How do you handle other problems in the facilities such as darkroom deficiency, shielding, this sort of thing?

MR. FRY: That's all in here. I didn't read them out detailed number by number, but there are points assessed, for example, if you don't have an automatic processor. Nobody says you have to have an automatic processor, but we feel it is advantageous, and a priority number is assigned, a small one, to those facilities that don't have an automatic processor.

Cliff Nelson from BRH in California.

DR. NELSON: What, then, has been your top priority radiographic unit? At any rate, I wasn't certain from your answer to Jerry's comment whether in fact you factored in the part of the body being exposed up to now in establishing your priorities.

MR. FRY: That has not been put in. This is a modification brought to light today.

DR. NELSON: I should take this opportunity to say that I am trying to encourage some States to give particular attention to those procedures that produce relatively high gonadal doses, particularly the examinations of the lower back associated with preemployment screening in industry and government. I have reason to believe that if you want the most "bang for your buck" in radiological health, that is where it is going to be obtained.

And I am really a bit dubious from what you have said so far that this system is going to accomplish that.

MR. FRY: My closing sentence was I believe this is a system for establishing priorities...there are surely others!

I think there was a second question from Georgia.

MR. BRITTON: How do you justify putting something in there like an automatic processor in assigning a place that doesn't have this some type of debit number? Because it has been proven that a good time and temperature system with hand developing over a long period of time would give you a much sharper radiograph with a lot less grain.

MR. FRY: There are a lot of modification factors in hand processing--"good," "controlled," "consistent." In many situations, such good hand processing doesn't occur.

MR. BRITTON: Well, then, if we go ahead and pass or try to get a licensing system in for technicians and have qualified people doing this work, then these factors will be there...or should be there.

MR. FRY: As I said, you can change these numbers. There are numbers, for example, in this same system concerning the operating personnel...are they registered x-ray technicians? What about the supervisory personnel? What is the background of the practitioner involved? These are also weighted points in the overall system.

MR. BRITTON: So, therefore, what your system is built up on presently will evaluate a program and give you some type of system based on the best you can obtain today, not actually what the best happens to be in a radiographic installation. Is that what I understand? In other words, you are not always in this program trying to shoot for an optimum radiographic installation, but some type of number that will allow you to weigh when you go in and make an inspection.

MR. FRY: Yes.

DR. KINSMAN: Thank you, Dick.

I want you to see the great strides science has made in the techniques of x ray. We will have the subject of improving techniques by a person who is very able and capable of doing this, Mr. Joe Brennan, New Hampshire Department of Health and Welfare.

Table 1. Debit points for radiographic machines not meeting stated criteria

Criteria	Debit points
Operating personnel	
Registered technician	3
Trained and experienced operators	6
Personnel monitoring system	3
Film and screen	
Film speed (fast)	3
Type of intensifying screen (fast)	3
Darkroom	
Adequate darkroom (clean, light tight, etc.)	2
Automatic process or thermometer used	2
Timer used	2
Filtration and collimation	
Proper filtration for kVp used	20
Rectangular variable aperature light-finding collimator	5
Adequate collimation	25
Timer	
Deadman exposure switch	1
Adequate timer	3
Protective devices	
Gonadal shield (primary)	3
Gonadal shield (secondary)	3
Adequate operator protection	5
Adequate primary and secondary barriers	6
Diagnostic type tube housing	5

Table 2. Debit points for fluoroscopic machines not meeting stated criteria

Criteria	Debit points
Operating personnel	
Radiologist	6
Personnel monitoring system	3
Equipment	
Image intensifying device	4
Accessory shielding	
Leaded gloves	2
Leaded apron	3
Bucky slot cover	1
Leaded drapes around screen	1
Dark adaptation	
Adequate dark adaptation	3
Usual operating procedures	
Ma <5	4
Time <5 minutes	4
Screen	
Screen ganged to x-ray tube	5
Screen cannot rotate out of beam	4
Leaded glass satisfactory	2
Shutters function properly	1
Useful beam limited to screen	10
Distance	
15 inches from target to panel	3

Table 2. Debit points for fluoroscopic machines not meeting stated criteria (Continued)

Criteria	Debit points
Roentgen output	
Output < 10 R/min at panel surface	5
< 5 R/min at panel surface	5
Filtration	
Proper filtration for kVp used	10
Timer	
Deadman exposure switch	1
Manually reset cumulative timer	2
Fluoroscopic room	
Light tight	1

Table 3. Debit points for dental machines not meeting stated criteria

Criteria	Debit points
Operating personnel	
Trained and experienced operator	6
Personnel monitoring system	3
Film	
Film speed (speed group, D or greater)	7
Darkroom	
Adequate darkroom (clean, light tight, etc.)	2
Thermometer used	2
Timer used	2
Pointer cone	
Open end	2
Filtration and collimation	
Proper filtration for kVp used	20
Adequate collimation	30
Timer	
Adequate timer	3
Deadman exposure switch	1
Stability of tubehead	
Tubehead stable	3
Protective devices	
Diagnostic type tube housing	4
Adequate operator protection	6
Gonadal shield (secondary)	3
Adequate primary and secondary barriers	6

IMPROVING TECHNIQUE

Joseph A. Brennan[1]

For the past 18 months, the x-ray survey methodology in the State of New Hampshire has been modified from the traditional emphasis on the physical attributes of x-ray equipment to a program dealing primarily with exposure techniques. The system involves an evaluation of direct exposure factors employed in dental and medical radiography. If I may I would like to discuss that which applies to dental radiography first.

A system was developed for the inspection of dental x-ray exposures which deals with exposure time and film development. It is based on a series of experimentally derived exposures unique to the various power factors of different dental x-ray units. For example, employing a Victoreen R-meter with a 0.25R chamber, we arrived at a value of 225 mR, measured at the cone tip, when dealing with a 65 kVp dental x-ray machine. That is to say, an exposure yielding 225 mR will produce an optimum bitewing radiograph.

When dealing with a 90 kVp x-ray unit, the optimum exposure is found to be 80 mR. The system presupposes that the beam size and filtration are equal to recommended standards and that the stated kilovoltage is fairly accurate.

In practice the method works as follows: The practitioner is questioned as to his normal exposure factors for bitewing films. Using his normal technique, we measure the exposure at the cone tip. We record it and compare it to our optimum figure. If this figure is higher than our optimum figure, we reduce the exposure time gradually until the optimum figure is approached.

Then, employing a dried human mandible with good dentition and ultraspeed film, a series of radiographs is taken using the optimum factors. These films are developed on the premises using proper time-temperature methods of film processing. The results are then discussed with the practitioner and compared to his normal radiographs. If he is pleased, and sometimes even if he isn't pleased, the suggested optimum exposure factors are left with him with strong suggestions that he employ them.

To date, 360 dental x-ray units have been surveyed. A reduction in exposure was strongly recommended in 210 instances with the average reduction approximately 50 percent. As most of you are aware, excessiveness in the so-called necessary x-ray exposure is a direct result of poor film processing techniques. The system is not perfect; we do feel, however, that it is practical. Radiographs produced on a dried human skull result in much greater detail than one can expect on living patients.

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[1] Deputy Radiological Health Representative, ECA, DHEW Region IV, Atlanta, Georgia. Formerly Radiological Health Consultant, New Hampshire State Department of Health and Welfare.

The so-called "mR" of exposure I referred to previously is actually an arbitrary figure and if it has any relation to the actual exposure, it is somewhat coincidental. This situation develops because an 0.25 R chamber is not wholly irradiated by an x-ray beam of 2.75 inches in diameter. We do feel, however, that the percent difference between the exposures is indicative of savings in radiation exposure to the patient.

Presently, we do not have much of an idea on the number of practitioners who have incorporated our suggestions into their techniques. This is planned for the summer. Cooperation among the dentists so far has been excellent.

So much for dental radiography. Now if I may, I will enter into the medical field.

As John Villforth stated yesterday, the latest statistics from the Bureau of Radiological Health's x-ray survey compilations show marked improvement trend and the requirements of Public Law 90-602 will, I feel, gradually result in a decrease in emphasis on the inspection of the physical attributes of x-ray machines at the State level.

The next logical, and perhaps most important step is the use factor, i.e., radiographic technique. Preliminary experiments directed at the production of high quality radiography, with emphasis on low exposure techniques, have indicated that reductions in the order of 10 to 40 percent can be made without unduly affecting diagnostic quality or the desires and satisfactions of the diagnostician.

It has been proposed that the advent of automatic film processors and rapid processor x-ray film has necessitated the development of optimum exposure techniques. It has, I will agree, considerably narrowed that region where witchcraft in the darkroom once compensated for exposure errors.

However, I also feel enough latitude remains which would lend itself to employment of lower exposure factors. Any reductions in exposure techniques in conjunction with the use of automatic film processing would, of course, be in the low area of that region I mentioned--somewhere around 10 percent, which I think would be an excellent reduction. This may not seem to be very much at first, but when one considers the workload associated with automatic film processors, this would be a considerable reduction in radiation exposure to the public.

Much greater reductions in exposure can be expected in facilities that do not employ automatic processors. The largest single group, with the exception of the dentists, in this area, of course, is the chiropractors. Exposure reductions here can be as much as 40 percent, and in many cases the quality of the radiograph can be increased tremendously.

As some of you are probably thinking right now, such activities as these will surely ruffle a few feathers. Individual practitioners and groups of practitioners may object strongly to activities and such proposals as these. However, I feel this may have also been the case when State health agencies first began physical surveys of x-ray machines. I feel that the public relations aspects of such programs will be as important, if not more so, than the technical aspects.

Before initiating activities in these areas, it would be of great benefit to call upon those individuals and groups who have had the most experience in the area--that is, the radiologists and technologists--in order that the technical basis of such proposals may be firmly based. The efficacy of activities in the technique area, I feel, should be tested by means of pilot studies in large and in small radiographic facilities, and these pilot studies should be conducted by radiologists and technologists with emphasis on low exposure techniques.

Thank you.

DR. KINSMAN: Anybody have any questions of Mr. Brennan?

MR. HARRIS: Joe, are we now getting into the question of optimizing dental and medical techniques?

MR. BRENNAN: Yes, sir. I think it is about time we start thinking about that.

MR. HARRIS: What reaction have you got, say, from the radiologists in the State with regard to individual preferences in diagnostic quality?

MR. BRENNAN: In the dental area first, I will just take the dental area, we have had excellent cooperation, very few problems whatsoever.

As you can imagine, in the medical area, as I did say, we have ruffled a few feathers here and there. I think that the program cannot be rushed. I think we need a lot of planning and a lot of background work. And we have to ask for their cooperation and maybe their initiation of the project or of the proposals. If they do it, it is their idea. And I think it will be more successful this way.

MR. HARRIS: Is there any scientific validity to the idea that you can vary the technique all over the place, get a different diagnostic picture, and still come out with the same diagnostic information?

MR. BRENNAN: I don't want to give the idea we will be varying the technique all over the place, Saul. Especially in large radiographic facilities, in the larger hospitals, any changes in technique may be quite minor. Just think about it for a second. A posterior-anterior chest radiograph is usually taken at 10 milliampere seconds and about 80 kilovolts peak. A 10 percent reduction in that is 9 milliamperes per second at the same kilovolt peak. That isn't much of a reduction when you think of it from the technique side.

MR. HARRIS: I wasn't talking about you making changes, but currently in diagnostic work with two radiologists, one will want a film very light and one will want one very dark. Is there any scientific validity to their arguments, not yours, that these two films give the same diagnostic information?

MR. BRENNAN: I think it is personal preference mostly.

MR. HARRIS: Is there any scientific validity to that personal preference?

MR. BRENNAN: I don't have any scientific validity for it, no.

PROFESSOR BLATZ: Hanson Blatz, New York City.

For many years I have been hearing people recommend increasing the kilovoltage in dental radiography. I have been raising some serious questions about whether this is right. Truly, you do reduce the skin dose from 225 mR to 80 mR. But how important is skin dose? When you raise the kilovoltage to 90, you increase the penetration.

There is beginning to be concern about the irradiation of the central nervous system. There is some good, scientific data on the treatment of ringworm of the scalp of children that indicates that exposure of the head is important. I believe more important than the skin dose is the integral dose to the entire contents of the head. And we mustn't forget that the cranium contains part of the blood-forming system. So I don't think that the criteria of the exposure of the skin has been really supported scientifically.

I also feel that we have attached too much importance to filters. A filter is a very easy thing to correct and bring up to standard. I don't think it is terribly important if you change from a one millimeter filter to a 2 millimeter filter, I don't think the critical organs with which we are most concerned, the gonads, blood-forming organs, and the central nervous system are very much affected. So I think that the optimum x-ray quality for dental radiography and also for some medical uses is an area in which there is need for some biological studies to find out what our criteria should be.

MR. BRENNAN: Hanson, I did not mean to imply that we recommended changes from 65 kilovolt peak to 90 kilovolt peak. What we recommend are changes in the mas technique, no matter what type of machine they possess at the time.

DR. KINSMAN: Any other questions?

MR. HARRIS: I have another comment. Nassau County and New York University's College of Dentistry did a study of dental x-ray machines in Nassau County a couple of summers ago. It is going to be reported out in the Health Physics Society Journal. They found out you cannot rely on a dental machine setting to tell you whether it is 65 kV or 90 kV peak. The half value layers actually turned over in a couple of instances regardless of what the dial said.

MR. BRENNAN: That's right, Saul. I did mention that we expect the kilovolt peak on the rated machine to be fairly accurate. Actually, we have figures in five kilovolt steps for all these various machines.

If the system doesn't work for us, what we thought was 85 kilovolt peak, we have different figures that we can apply for 70 or for 55. And we do bracket our exposures. In other words, we take a half a dozen exposures. Even though our system may not be perfect, one of those films will be, hopefully.

DR. KINSMAN: Any other questions.

The next speaker has already made a presentation to you. This gentleman has furnished more of the people in the radiation control and inspection program for California than anybody else.

For regulatory changes for effective programs, we would like to hear from Mr. Hanson Blatz, New York City Health Department.

REGULATORY CHANGES FOR EFFECTIVE PROGRAMS

Hanson Blatz[1]

Most of us are quite familiar with the general pattern followed by radiation control regulations. They generally cover specifications of units of measurement and dose, various permissible levels of radiation and dose rates for different classes of individuals or for persons located in different areas, details of radiation surveys, personnel monitoring, recordkeeping, reporting, caution signs and labels, instructions and notices, storage, waste disposal, contamination control and sometimes certain aspects of transportation. When we attempt to judge most such regulations objectively as they might apply to a user of a radiation source or one of us responsible for enforcement, we must admit that it is a hodgepodge of arbitrary rules developed over the years mostly by expert committees without any real systematic organization. In reviewing the rules and the manner of administering them we often find it difficult to distinguish between a rule that must be followed to comply with the regulation and a recommendation that, as the NCRP expresses it, "Should be applied when practicable."

It would seem that there should be a better organization of the rules that apply and that they should be classified in certain separate categories. Radiological health and safety depend upon several elements namely, radiation sources, their users and their use:

Sources of Radiation: In this case, medical and dental x-ray equipment and their accessories, should be designed and built so that radiation of the optimum energy, quality and quantity can be easily applied to the exact part of the patient's body where it is needed so that the radiation can be used most efficiently to produce the desired effect.

Equipment operators, observers and neighbors can and should be exposed to practically no stray radiation and there should be little risk of exposure through misunderstanding, carelessness or error. Patients must be exposed only as much as necessary. I have had arguments with people who say, "How about bedside units? How about fluoroscopes?" For these, I think we have to take a fresh look. They could be designed so that the person using them isn't exposed, but it will take some work.

Perhaps the most important improvement that could be made in the requirement for x-ray equipment itself under a realistic set of regulations is as follows. The operator should be able to set the controls for a desired kilovoltage, milliamperage and time interval, or as an alternative, a combined setting for milliampere-seconds. Of course, automatic controls of some of these factors can be justified if they work right.

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[1] Director, Office of Radiation Control, New York City Department of Health.

Saul Harris gave you a small example. We have seen where machines set for exactly the same kV and milliamperes don't deliver the same sort of radiation. I think each of you can test this out for yourselves.

Most importantly, the operators should be able to adjust the x-ray equipment easily to make certain that the x-ray beam will cover only the area of the x-ray film and in some cases a smaller area. To me it seems incredible that a photographer can see in advance through a viewing system, exactly what will be on his picture when it is developed and that the operator of moving picture equipment in a theater can adjust his projector so that it strikes a screen several hundred yards away within fractions of inches, yet with the average x-ray machine used at a distance of only from 30 inches to 75 inches from the source to the film, we have had vigorous complaints when we have allowed a 1-inch margin of error in aiming a circular beam.

To me this is one of the most important improvements that should be required in modern x-ray equipment. The next time you have the opportunity of watching the operator of a TV studio camera move his equipment around, try to recall the struggling x-ray technicians you have seen and compare the techniques.

After the control has been properly set, the film placed in position and the x-ray beam direction adjusted, the operator should be able to see readily whether the technique he has selected has been met. This often is not the case. Some of these factors are sufficiently important to require independent checks. Some of you may recall that years ago because of a few failures of milliammeters on x-ray therapy equipment, it was often specified that x-ray therapy controls should contain two milliammeters. You may also have noticed that generally the two didn't agree. I don't suggest this as a solution, but I believe that some thought should be given to checking techniques much in the same category as the key punching of cards in a computer program where every punched card is checked independently before the program is initiated.

To obtain comparable results, there can be a wide variation in the electrical factors used on different x-ray machines, for techniques that are identical, as Saul Harris mentioned before. This indicates that there can be large errors in the controls or the metering systems being used today.

I learned that the age of an x-ray tube has something to do with the quality of the radiation. It has quite a profound effect on the quality of the radiation. This is being studied, and some correction should be made for that.

It would be hoped that standard techniques could be developed. We spoke of the wide variations in the techniques a little while ago. I think one of the reasons for the wide variation in techniques is because you can't adopt standard techniques because you don't get standard output from different machines.

Standard field testing procedures should be devised for testing the electrical factors after installation. Electrical supply line specifications should be established to assure a reasonable degree of stability. This is also another frequent source of failure.

Users of Radiation Sources: This was mentioned yesterday several times.

One subject that should be discussed and agreed upon is the determination of the necessary training and experience qualifications a person must have before he is permitted to use medical or dental x-ray equipment. It appears that most dentists have had considerable basic training in the use of x-ray equipment, but this training is quite variable and should be made to meet certain standards.

In the case of physicians, it is obvious that many of them who have used x rays in the past have not had adequate training or experience. Some have had no training. The same applies to many x-ray technicians.

Many years ago this subject of training could not be mentioned in the presence of physicians without stimulating arguments about interfering with the practice of medicine by licensed physicians. In recent years, there has been evidence of a subtle change in attitude. Many physicians today will agree that some evidence of qualifications should be required for those who wish to practice even a limited amount of radiology.

Perhaps the notably successful program of the licensing and regulation of users of radioactive materials by the Atomic Energy Commission and now by many Agreement States has convinced physicians that such a plan can be beneficial to the practice of radiology as it has been to the practice of nuclear medicine.

We have also been encouraged by recent efforts to place x-ray technologists under a licensing system. Unfortunately, the use of a grandfather clause, which cannot be avoided whenever a new licensing program is started without causing a severe hardship to many people, will mean that the complete effect of any such licensing program will not be felt for a generation, when all the poorly qualified grandfathers retire. This is one reason why the problem is so pressing.

Use of Radiation Sources: It would seem that if provisions are made in regulations to limit the use of x-ray equipment to persons who are properly trained and adequately experienced and if performance specifications are developed to require that the equipment and its structural shielding is virtually foolproof, which it is believed can be done, there should be little need for regulations covering the healing arts use of x rays. The problem of excessive use or unnecessarily repeated examinations are abuses that could not easily be regulated under any circumstances. Popular feeling and professional education has and will probably continue to be the only effective controls.

And I don't think we should overlook popular feeling. Those of you who have been in the field a long time know that it was once the practice of pediatricians to fluoroscope babies and young children every month and when they had the annual checkup. When we questioned this practice, pediatricians would say, "Well, the parents expect it. They think if I don't fluoroscope the patients, they are not getting a complete examination."

Well, time changed. We had fallout, then we had the National Academy of Sciences Report pointing out the dangers of x rays, and now today pediatricians say that when they want to fluoroscope or x ray a child, they often encounter parent's resistance. As a result, there is very little routine fluoroscopy being practiced today on young patients. I think this sort of result of the population's education is most important in any improvements we want to make.

Regarding the problem of repeated chest x rays, we have many complaints from individuals who say, "I am taking a new job, and they want to do a chest x ray. I had it done just a few months ago by somebody else. Is this right?"

I think this feeling, this reaction of the public is going to be helpful to us. But I think we have to do something to stimulate it properly without frightening patients.

It would appear that serious consideration should be given to the licensing of x-ray sales, installation and servicing. Many of the deficiencies that have been found in x-ray installations, and particularly in the case of reinstalled used equipment, have resulted from careless service or a misunderstanding of some of the basic concepts of radiation protection on the part of mechanics and electricians who do the work. This would be best placed under control by a licensing system.

General Character of Regulations: Many of these I don't particularly care for.

A regulation may be either of two broad types. It may either be objective or dogmatic. If we were asked to choose, we would probably all choose and often have chosen an objective approach for regulating radiation, the choice being based upon our scientific training and experience.

In the past, the basic criterion for radiation protection has generally been the specification of a maximum permissible radiation dose that each specific critical organ, or the whole body may receive. It is obvious that in any particular case of a suspected overexposure, it is virtually impossible to determine with any reasonable degree of certainty whether such a limit has been exceeded or not. It has never been clear to me how the "dose to the whole body" is determined. Yet, it is in every regulation.

There are, however, a few arbitrary limits that have crept into radiation regulations over the years. One is the patient exposure rate limit of 10 R per minute allowed during routine fluoroscopy, which has been recently reduced by some agencies to a figure of 5. Another is the AEC value, adopted by many States, of a radiation limit of 2 mR in any hour in a noncontrolled area.

The radiation leakage limit from different types of x-ray tube housings and of teletherapy source housings are quite arbitrary but on the other hand are easy to observe and to enforce and generally are not considered unreasonable.

In attempting to interpret some of the recommendations of the NCRP which have been applied in the Health Code of New York City, we have often been involved in endless discussions about reasonable workloads, use factors and occupancy factors for ancient x-ray installations, where the shielding is obviously inadequate according to present day standards and could be quite inexpensively supplemented in terms of the total cost of the complete x-ray installation.

Some installations with questionable protection have been defended by carefully juggled estimated workloads, use and occupancy factors that cannot be easily verified. An agency would be required to demonstrate that some individual's gonads or blood-forming organs had, in fact, been overexposed according to the standards to have an enforceable case.

If we look at other health and safety regulations that withstood the test of time, we see that there has been a trend away from objective regulations and toward dogmatic ones as being less debatable and more likely to be enforced uniformly and fairly. France has recently left the ranks of countries permitting prudent or safe automobile driving at any speed and has established speed limits for its *autoroutes*. Many other examples can be given.

The validity of each such arbitrary limit, whether it be the maximum number of diners in a restaurant or the maximum floor loading in a loft, can be debated, but experience shows that the principle works better than objective approaches in maintaining safety.

In planning or evaluating the radiation protection afforded by structural shielding, which relies upon the employment of estimated workloads, use factors, occupancy factors and maximum permissible doses in one of two categories to determine what amount of structural shielding is adequate, it often becomes an exercise in speculation. When the total cost of a diagnostic x-ray room including the equipment, its installation and the structural shielding is analyzed, the difference between one millimeter or three millimeters of lead in a wall (the thinnest and the thickest sheets usually required) would hardly be noticeable.

I should recommend that it would probably be much better and certainly much simpler, always to plan for the maximum possible workload, the maximum worst possible combinations of use factors and full occupancy and to provide adequate shielding for any possible future use.

There has been one trend in that direction you may recall. In Handbook 76, for controlled areas, if there were a toilet to be shielded, it was allowed an occupancy factor of 1/16. If it were an office, it was some other value, for the corridor something else. But there was a change recently in the new report on structural shielding which changes the occupancy factor for all controlled areas from various values to unity with the reasoning that radiation workers, whether they are at the controls of an x-ray machine or in the toilet next door, should be given the same degree of protection all of the time. This seems reasonable, and the added cost is not significant.

We must also consider the fact that all of us today are being exposed to more and more sources of radiation. We can no longer be satisfied with keeping people's exposures below 100 mR per week or below 10 mr per week from each source. It should be kept to the lowest value practicable.

In conclusion, it would seem, then, that several basic changes in regulations to protect people against x rays should be made. There are several reasons for increasing our efforts to reduce human exposure to radiation to the lowest feasible amount subject to practical and economic considerations, rather than just below the maximum specified permissible doses in each case.

Over the years, there has been increasing evidence of the biological effects of small exposures, particularly from a genetic standpoint. The constantly increasing exposures and numbers of people being exposed from increased use of nuclear energy, its byproducts and wastes, and the sharp increase of medical services, including x-ray examinations to more people are all good reasons for vigilance. The recent reevaluation by the AEC of some of its radiation protection standards for reactor effluents and the reported HEW Staff Paper to the Federal Radiation Council recommending a reevaluation of its guidelines bears this out.

Several changes in basic principles of radiation protection regulations as they apply to x rays are recommended.

1. Establish national equipment performance standards that will permit a uniformity in selecting and easily applying x-ray techniques. This is not now possible with present equipment. I acknowledge that this project has been initiated by the Bureau of Radiological health and they are making progress with it.

2. Initiate the research and development of improved x-ray equipment, particularly as used in fluoroscopy and for bedside use with the objective of eliminating stray radiation as completely as possible. Performance standards should then be prepared.

3. Review systematically all of the common deficiencies of existing x-ray equipment and its structural shielding to determine to what extent it should be modified to meet modern safety standards. A revised and comprehensive set of standards should be agreed upon, amended to existing regulations and uniformly enforced.

4. Initiate procedures for establishing minimum training and experience qualifications for all professional users of x-ray equipment and for x-ray technicians. A start has already been made in several States on this.

5. In the planning of expected exposures to stray radiation, as in structural shielding planning, discard the principle of designing to keep exposures just within permissible doses and substitute the principle of minimizing as much as practicable the stray radiation doses to each person. Design structural shielding so that the equipment workload and use-factors can be the highest values credible rather than based on expectations at the time of installation. Some conservative designers are already doing this.

Maximum permissible doses should be employed primarily in evaluating possible overexposures rather than in the planned exposures of humans.

6. Each x-ray tube mounting should be provided with means for mechanically restricting its range of beam direction. Then the adjacent wall of any occupiable space that the beam can strike should have a primary protective barrier depending primarily upon the kilovoltage capacity of the machine and the distance.

7. The concept of controlled and noncontrolled areas, except for the x-ray room itself should be discarded. All possible occupants, including transients, should be given the same high degree of protection in any occupiable area.

Thank you.

DR. KINSMAN: Any questions?

We allowed time for stimulating discussion.

PROFESSOR BLATZ: I thought I would start some arguments.

MR. COLLINS: John Collins, Massachusetts.

In essence, you are calling for standards. As I relate this, say to air pollution and water and so forth, you are looking for a maximum application of technology and design and so forth. In one sense, it appears to me you ask for standards and yet at the same time, you don't want standards. I am thinking now of the President coming up in a related area, saying to Air Pollution, "Consider the adopting of emission standards for use at air pollution control facilities." In this meeting, such a standard doesn't call for a maximum effort towards applying maximum technology. So, I became a little confused.

PROFESSOR BLATZ: Well, I certainly didn't express myself adequately if you think that I don't want standards. I want more dogmatic standards. I like the standard that the AEC has of not permitting over 2 mR per hour in noncontrolled areas. This is something that can be checked and enforced.

But the idea of determining how much the machine is likely to be used, what direction it is pointed, how likely someone is to be there and what category of exposure, whether or not he is a radiation worker or a member of the general population, I think these are the sort of controls I would like to see revised. I would like the radiation levels in every occupiable place brought down to a point where a person can stay there.

MR. COLLINS: Where you apply the maximum technology to reduce it to the lowest level irrespective of whether your data are saying you can't achieve a certain level. In other words, you want to apply the maximum, but this is contrariwise to a standard, which is my point.

PROFESSOR BLATZ: Our definition of standards must be different. I will talk to you later.

MR. HALPERIN: Hanson, I detect some ambivalence in what you are saying in terms of your request for more dogmatic standards and yet advising or suggesting that we do away with things such as the concept of the maximum permissible dose which to me is a dogmatic standard. How in a regulatory program can you then determine compliance with a regulation where there is not a number upon which to say that a situation is in compliance and its people are not being exposed to radiation levels greater than the standard?

PROFESSOR BLATZ: I did say somewhere here that the maximum permissible dosage should be used to determine whether or not a person has been overexposed.

MR. HALPERIN: I don't see how that fits into a compliance program, though. How can you use it to determine compliance?

PROFESSOR BLATZ: Limiting ourselves to, say, a medical x-ray installation rather than calculate how much lead is needed in the wall, based on the likelihood that an individual is there one-sixteenth of the time when the beam is pointed at that wall a certain fraction of the time under a certain workload. Instead of doing that, say the next room should not have more than so many mR per hour with the beam pointed at it or something of that order.

Using maximum workloads, maximum use factors and maximum occupancy factors, I think the cost would be so slight in comparison to the whole cost that we could shield a room that way and forget about it forever.

MR. HALPERIN: So what you are saying is that you are just changing the kind of dogmatic standard you would have. Instead of a dose to a person, you would have an exposure level in the other room.

PROFESSOR BLATZ: This is an indirect objective standard. The reason why lead is put in a wall now is to make reasonably certain that nobody in the next room is going to have a dose to the gonads or blood-forming organs in excess of a certain amount. That, to me, is an objective standard.

MR. HALPERIN: It is really the same thing as shielding a tube head--no more than so much of an exposure rate at the other side.

PROFESSOR BLATZ: Not quite. Nobody has ever calculated to my knowledge the amount of time a person is at a certain distance from a tube head and shown how this is related. This is one criticism I have of that standard.

Why do a dental diagnostic x-ray tube head, a fluoroscopic under-table tube head and a diagnostic radiographic tube head over the table all have the same permissible leakage? There is no reasoning to it, because they are used in entirely different ways. The dentist and patient are very close to that dental tube. In the case of the radiographic tube, nobody is near it except the patient. These are just arbitrary numbers that have been assigned.

MR. HARRIS: I take it, then, that what you are proposing is consistent with what Joe Brennan is talking about. That is, optimization right down the line both as to equipment, users and use of medical and dental x-ray equipment.

PROFESSOR BLATZ: Yes.

MR. HARRIS: Would you recommend, then, that a committee be established by the Bureau of Radiological Health to get inputs on what this optimization ought to be or how do you think that the mechanism could be established to start looking at optimization?

PROFESSOR BLATZ: Well, when you say committee, I shudder but I do think some thought has to be given to it, and that's what I hope to stimulate today. I think that in the case of medical x ray, it is quite simple. We know from the tube manufacturers ratings the maximum amount of x-ray machine can be used without overloading the tube. Let us shield the room to take care of that. And for every wall towards which the beam can be directed, either shield it completely or fix the tube so it can't be directed at that wall.

There is too much dependence upon the honor system today, and too much speculation about how equipment is going to be used in the future. This causes us many problems and much uncertainty. I think we are particularly sensitive to this in New York City because we have a much higher percentage of ancient x-ray installations which were built many years ago when the standards were quite different. When we make an inspection and claim that the shielding is inadequate, the owner very often will say, "Well, there is a very low workload, and the tube is pointed down practically all of the time." Without some solid evidence that someone has been or is likely to be overexposed, the installation can continue operating with substandard shielding.

People are being unnecessarily exposed to radiation. Even if it is within permissible limits, it is more than they need be exposed to.

MR. HARRIS: Then, the next question that comes along is: Do you think we should now get into the question of specifying optimum films and film screen combinations for use in different techniques?

PROFESSOR BLATZ: This is a good question.

Incidentally, I would like to answer for everybody your question you asked before, while I think of it. You had a question about the amount of information on an x-ray film.

Eastman Kodak people have been studying this for years. They have been doing some pretty objective testing among radiologists with different types of films...and the information on the film, the physical information, is only part of the impression a film makes. Psychologically, one radiologist will get more information from one type of film whereas another radiologist can diagnose better from quite a different type of film. If you switch films, neither will get all the information they have been trained to get. It is not a simple problem.

MR. HARRIS: Then it is their training.

PROFESSOR BLATZ: To continue with optimization, we are trying to do this in the case of dental x rays. About three years ago, one of the leaders in the dental profession--I think he was the president of the American Dental Association--said, "Now that dentists are using ultraspeed film with pinpoint collimation and split second timing, we have done all that needs to be done to reduce the dose to the patient."

We said, "Well, let's check this." We asked our inspectors to check the films being used. We found out that only 37 percent of the dentists in New York City were using fast film. Forty-one percent were using the slowest films on the market, usually because they had old mechanical timers and also because slow films give a great deal more latitude. They can be overexposed or underexposed and still result in a diagnostic film.

We issued a warning that unless this were changed, we might find it necessary to amend the Code to require fast films for routine dental radiography, admitting that there are certain techniques where a dentist will use a magnifying glass and wants a fine-grained film. This is a threat that may have been empty. I don't know whether we could have carried it out...but we have stimulated enough interest so that two years later, 58 percent of the New York City dentists were using fast films.

So I think a great deal of attention has to be given to film speeds, screen speeds, and also the sensitivity of phosphors used in image amplification.

I have learned recently that some manufacturers have gone back to using a slower phosphor, exposing the patient to much more radiation because they get a better appearing image with more contrast. It has better sales appeal to physicians because it makes one piece of equipment look better than another. This is something that has to be watched. I think that phosphor standards should possibly be set.

DR. KINSMAN: Yes, Don.

MR. KURVINK: Don Kurvink from South Dakota.

I would like to say I am much in agreement with your suggestion. However, in a less populated midwestern State I think the practicality of the suggestion probably isn't as great as you may find in New York. I have been through this on a few installations, for example in a therapy facility where using the maximum workload would mean a difference of having or not having the therapy capability in the facility.

I wish that we could go along with your suggestion entirely because it would be much easier.

PROFESSOR BLATZ: You are talking about the structural shielding for therapy? I would agree with you that this presents more of a problem. I think we could look at the way in which the cobalt teletherapy restrictions have been handled under a very strict AEC regulation. In cobalt teletherapy, the way we enforce it in New York, is that if someone feels he has to use a horizontal beam for certain techniques, he must select which wall toward which he wants to direct the beam. Then the mechanism is limited so that the beam can point only at that wall, and that wall is quite adequately shielded.

MR. KURVINK: I think the same thing applies in our area to cobalt therapy. In many cases, the cost of the facilities and the design requirements you impose may mean the difference of whether these people have the service or not in that particular locality.

What I am saying is you can justify this in New York with a very busy situation, but as you get in a more remote area, these requirements may actually preclude the service. We would look at this very carefully before we would apply this kind of standard.

PROFESSOR BLATZ: I have done some rough calculations on this in which I took a typical diagnostic x-ray installation and found out what it costs, including the cost of different amounts of shielding. In the case of orthovoltage therapy, I will admit, there is some question, but in a diagnostic x-ray machine, the difference in total cost is slight.

DR. KINSMAN: Any other questions?

Thank you, Hanson.

I would have a question, but rather than answer it, I will say that you are going to hear considerably more about this before the Conference is over. There is a committee on priorities. And a part of a challenge for that committee is how can you upgrade the competence of the users of radiation? And as Hanson Blatz has suggested, not only the person dispensing the x ray needs to be controlled, but the sales agent and the installer, I think, are big factors here that we haven't had enough control over as yet.

We are fortunate in having a radiologist here who can tell us how the radiation exposure to the general public is being reduced drastically in their profession. The subject is Technique Trends in Radiology by Dr. William Cole of Johns Hopkins University, the Public Health Service and all places east.

TECHNIQUE TRENDS IN RADIOLOGY

Reynold F. Brown, M.D.[1]

Presented by
William S. Cole, M.D.[2]

This is the second time I have come to this convention and presented a paper written by someone else. Last year, you might remember that I read a paper that Dick McDowell had prepared. He unfortunately broke his leg a week before that and was unable to attend. So I presented the paper.

This paper was prepared by Dr. Reynold F. Brown and Bruce Burnett. Bruce is a PHS officer with the Bureau of Radiological Health and an Assistant Project Officer of the Radiological Health Science Education Project at the University of California.

Now, who is Reynold Brown? Dr. Reynold F. Brown is Professor of Radiology and Director of Environmental Health and Safety at the University of California Medical Center. He is Chairman of the Medical X-ray Advisory Committee to the Bureau of Radiological Health. He is also the Chairman of the Board of Directors and President-Elect of the Radiological Society of North America. He is also a member of the NCRP and at last report was a member of the ICRP. Ray is also the man who guided the California bill with which I think most of you are familiar. Without his service, this bill would never have passed the legislature.

The title of this paper is "Technique Trends in Radiology," and it seems rather appropriate to discuss it at a meeting concerned with radiation control.

At first glance, the subject would appear to be quite simple in that it is relatively easy to review the published literature of the current year and do a statistical analysis of the papers that are written or presented at the scientific meetings, and by analysis, make some projections concerning the areas in which radiology moves or appears to be moving. However, if one views the subject with a historical reference, the trends that are presently evident in radiology had their beginning a great many years ago.

For example, by 1910 and 1912 a considerable study of the use of contrast material had been made, but it was not a practical medical procedure at that time. For one reason or another, including toxicity, the media were unsuitable for use in humans for medical diagnosis or therapy.

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Cine-radiography was developed approximately 40 years ago, but was limited by the lightgathering power of the available lenses. The result of this limitation was to deliver considerable exposure to the patient, and its advantage over the single exposure film was questionable in most instances. The development of electronic amplification techniques and improved lens systems has made cine-radiography a routine diagnostic procedure.

The popular diagnostic technique, mammography, had its historical roots almost 40 years ago. What seems to be required for the widespread use of a particular technique is not the new and original concept of a technical examination, but rather a significant improvement in engineering or physiological chemistry that sometimes results in the applications of new materials to older techniques.

What I am leading up to is the opinion that the trends of today may not be the trends of tomorrow. For instance, if there is a technical or engineering breakthrough by an allied professional group, so that solid state image intensification becomes available, and screen sizes can be full-scale, there will be considerable change in the technical aspects of diagnostic radiology. It might eventually be possible, by such techniques, to do away with x-ray film.

However, the literature today does not forecast the elimination of the use of film as the most sensitive recording device available.

In diagnostic radiology, the first objective is detection of the abnormal. This abnormality can either be a static display, such as a lesion or defect in the tissue of the body, or it can be dynamic in that the normal function or movement is impaired and is presented as an abnormality of function.

There is at the present time considerable development of technical procedures that attempt to combine the advantages of the static and dynamic examinations.

In addition, there is a particular interest and effort made to opacify and differentiate all the soft tissue and bony structures of the body. This opacification can be accomplished in nearly every area by one means or another and in some cases, internal radioisotopes that transmit their information by emitting ionizing radiation to the receiving system, can be utilized.

The end result of all these systems is to produce information in abundance. Where we once had a single film, then 10, we now may have 100 images, recorded over a short time period.

The experienced radiologist performing a gastro-intestinal series has a fluoroscope viewing time of less than five minutes in the majority of cases. Only in a rare and complicated case will he require more than five minutes of viewing time.

In some of the newer special procedures, such as heart catheterization, with the injection of contrast media and the recording of the anatomy and dynamics of the heart and adjacent vascular systems, we can commonly observe fluoroscopic viewing times of 45 minutes per examination.

Some observers have remarked that we may be drowning in a sea of information and that we are in many cases producing more information than necessary for only a diagnosis.

For example, a surgeon contemplating an exploratory chest operation will be interested in the vascular structure of the chest in the area of his proposed operation. Anatomy books present this material as if it were a rather uniform phenomenon, but, in fact, the variation from patient to patient may be considerable and if the surgeon does not know the anatomy to be encountered, this operation may be greatly complicated. Therefore, his interest in this information is not in the ordinary sense a diagnostic radiological examination.

This illustrates the kind of examinations related to physiology as well as structural alterations which are important in special procedures. And if there is a trend in diagnostic radiology today, it is in special procedures.

Special procedures in most x-ray departments are important in the amount of space allotted to them; in the amount of staff allotted to them; in the amount of time allotted to them; and they are requiring radiologists to assume a new role in many areas. The radiologist is becoming more of an operator, working directly with the patient, rather than a director of a department where the operational aspects are largely conducted by the technologist. This trend is important for those of us interested in radiation protection and control.

Our original approach to equipment, protection and departmental design, had been predicated on removing the radiation worker from the area of exposure and placing him behind protective barriers built into the installation. In many special procedures, the radiation workers are inside the protective barriers adjacent to the patient. And each of these procedures must receive special attention for the protection of the members of the team.

The first is a cardiac catheterization procedure using a bi-plane fluoroscope. The amount of equipment that is necessary in these procedures is great. In many institutions, a radiologist is not a member of this team even though this procedure may be under the general direction of the department of radiology. The services of the radiologist are usually to locate the catheter and to tell the other members of the team where the catheter is. This aspect of the technique can be learned by others who do it regularly and actually become very adept at determining this location.

In time, many radiologists get bored with spending hours with no other function than to tell somebody else where the tip of the catheter is at any precise moment. They tend to withdraw from the team and we are left with a team that does not include a radiologist and here radiation protection can break down.

Even though good protection procedures are developed, intermittent surveillance is a necessity. In teaching hospitals where residents rotate through the special procedures, constant education is necessary to maintain radiation exposures within the occupational limits usually considered appropriate for radiation workers in this category.

Next is a cerebral angiogram which is a contrast study of the blood supply of the brain. At the University of California there was developed a teaching technique related to the imaginary visualization of the cone of radiation with its apex at the tube and its largest diameter on the floor of the procedure room. All members of the operating team are required to have knowledge of the dimensions of this beam. Therefore, they know where the primary beam is at all times--supposedly.

We have removed the hands of the surgeon from the primary beam, and he works at some distance through the use of tubing of one type or another.

The point I am emphasizing is that you must develop procedural techniques for special studies in order to preserve radiation protection.

MR. HARRIS: Is that localized shielding on the patient?

DR. COLE: I don't know. He is supposed to be protected.

The pneuo-encephalogram is one of the oldest of the special procedures and one which ordinarily does not require a team effort. Air is injected in the spinal canal, the patient positioned, and the multiple films exposed. The examination may be conducted without undue potential for radiation exposure to the radiation workers.

The portable image intensifying fluoroscope is a device which is very popular on surgical floors and, again, a great many people other than radiologists are using and operating these instruments. At the University of California, there are some 80 people listed as qualified to use this instrument in surgery. Fortunately, the 80 named people do not use it with any great frequency. It may be used routinely by other than a radiologist where immediate information is desirable.

And by that, I would imagine that Dr. Brown meant the location of a foreign body, the insertion of a hip prosthesis in the surgery, in which case the exact location must be determined.

The polytome involves a rather complicated movement of the tube head. For example, skull tomography may deliver as much as 10 R to the lens of the eye. For this reason, technologists should use eye shields for patients who are undergoing this particular examination.

As a matter of fact, these shields could be used in other than the polytomographs of the skull. Here, again, the point to be made is that every time an improvement or new technical procedure is devised, there is a need for a review of the radiation protection procedures.

In conclusion, for those of us concerned with radiation control, there is a continuing need to be aware of the developing trends in diagnostic radiology.

I would be willing to try to answer questions that seemed to come up this morning relating to the clinical use of radiation.

I wear two hats at the moment. I am full time at the Johns Hopkins Hospital, but I will be returning to the Bureau of Radiological Health in Rockville approximately the first of August at which time I will assume another hat. If you have any questions about the clinical use of radiation, I would be happy to try to answer it for you.

DR. KINSMAN: Marshall Little.

MR. LITTLE: I have seen a trend away from the control of the radiologist. You mentioned this very briefly, but I wonder if you agree that this is a trend in most hospitals. These special procedures are being conducted more and more without being under the control of the radiologist.

DR. COLE: Marshall, I agree with you. Dick Olden sitting there knows more about the special procedures at Johns Hopkins than I will ever know. I think Dick would agree with that.

For example, our pediatric cardiology laboratory is under the immediate supervision of a pediatric cardiologist, but under the general supervision of our department. Is that right, Dick?

MR. OLDEN: That's right.

DR. COLE: Marshall, I agree with you. I think there is a trend away from immediate supervision by a radiologist, but you want to remember that there is a shortage of radiologists. It is impossible for them to be intimately concerned with all the procedures that take place in a diagnostic department.

At Johns Hopkins Hospital, for example, I think we do between 500 and 600 diagnostic cases a day. It is impossible for a radiologist to be in attendance at all times. Does that answer your question, Marshall?

MR. LITTLE: What is the solution as far as radiation protection is concerned?

DR. COLE: I don't know.

MR. HARRIS: It is obvious there is a radiologic technologist present, is that right? That's the solution.

DR. COLE: Saul, I agree with you. I agree with the idea that Dr. Dick Lester has at Duke University in the training of technologists to really assist and perform many of these procedures. This would include fluoroscopic examinations perhaps even to the point of passing catheters. There is, however, a difference of opinion on this. But I think that we must go forward with this idea to find out whether or not it will work.

Dr. John Campbell at Indianapolis, for example, has been doing the same thing. So in a sense what I am saying is that education is the answer to this problem. I am firmly convinced that education of medical students in radiology is not only important, it is a necessity. And not many schools really have prescribed courses in radiologic protection. These men see the finished film.

I think those of us who attended the hearings held two years ago by Senator Bartlett were made aware of this fact when he asked Dr. Chamberlain of the University of Pennsylvania how many hours of exposure did the students receive in radiologic protection. It came out as four hours.

I was at a meeting in New York in January, the radiologic undergraduate seminar, which was attended by approximately 90 representatives from the 100 medical schools. There is definitely a trend to try to educate the medical students in all aspects of radiology beginning at the first year level. At Johns Hopkins, Dr. Morgan may join with Dr. Reynold Brown of the University of California in developing the system that is now in effect in California.

Any other questions? Nothing controversial?

DR. KINSMAN: He thought you were really going to have a challenge here. Nobody has any questions on radiology at all, how they do it?

DR. COLE: Why we do it.

DR. KINSMAN: Why you do it and why you don't do it better.

MR. STEIN: I would like to know first with the 25 percent you say for chest catheter is 45 minutes, how long is the fluoroscope on generally speaking?

DR. COLE: How much on time? That is a tough one. I would say it varies with the patient. In a difficult case, some of the congenital cardiac abnormalities, it can last a half hour, 45 minutes. But in that particular examination, the radiologists are not really concerned about the exposure because this is an attempt to make a diagnosis which could be life-saving.

DR. KINSMAN: Thank you, Bill.

Saul did make one good point that will be discussed in detail, I am sure, at the rest of the Conference.

Now, we have heard about people and trends, we want to learn something about the evaluation of equipment and then conclude this session with record management.

This afternoon, the person who is going to present the topic of evaluation of new equipment was asked a question down at the University of Nebraska at a dental radiological workshop: Well, Dale, how do you like it now that you are retired?

And he said, "I never worked so hard in my life, but it is a lot more fun putting out fires I start rather than putting out somebody else's fires."

This fellow will tell it to you as he sees it. He is not going to hold back anything. I would like to introduce Dr. Trout from Oregon State University.

EVALUATION OF NEW X-RAY EQUIPMENT

E. Dale Trout, Sc.D.[1]

Since the development of alternating current high-voltage transformers, the emphasis in the United States until recently has been on the use of two types of x-ray equipment: (1) light weight self-rectified equipment for bedside radiology or radiography, and (2) full-wave, single-phase equipment for use in fixed installations.

As demand increased for mobile equipment capable of operating at higher currents, and as new hospitals were built having room and ward electrical systems capable of supplying higher power bedside equipment with increased power ratings, these units became available. More will be said about this later.

In Europe where electrical distribution systems have had low reserve capacity, three-phase equipment has been popular for many years. There is nothing particularly new about three-phase systems which have from time to time been available from United States manufacturers. As a matter of fact, the first three-phase equipment that I know about was built using mechanical rectifiers in the early 1920's.

As high-voltage, high-vacuum rectifiers, so-called Kenotrons became available, at least one manufacturer made available three-phase equipment using high-vacuum rectifiers. Mechanical circuit breakers were used with these poly-phase systems. The fact that such equipment never became popular in the early to middle 1930's was largely due to the problems encountered with the timers and circuit breakers because it was very difficult to get all three phases to break at zero voltage.

With the advent of electronic circuitry and associated solid state rectifiers and control components, three-phase systems providing satisfactory operation are now available, and you will see more and more of them. At the present time, about 40 percent of the equipment being purchased in the United States for fixed installations is three-phase equipment.

Most of this equipment is rated at tube currents of 500-2000 milliamperes. Lest it be thought that this is the first time high-powered equipment has been available for diagnostic procedures, it should be pointed out that equipment operating at tube currents up to 1000 milliamperes was available in 1934 and was operated at that current. Tubes capable of handling such currents were also available at that time. This was before the advent of the rotating anode tubes and focal spots were, of necessity, larger than those available today in either conventional or high-speed rotors.

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Then, too, there was the problem of timing exposures. Satisfactory single-phase timers were developed and gave no problem. The development of electronic components in the mid 1930's led to attempts to provide switching and timing systems using some of these electronic components.

One system involved a high voltage switch tube with a smaller, low-power, low-voltage vacuum tube used to control the grid in the switch tube. A system using this method of switching was one of the first to make use of the capacitor-discharge concept wherein a bank of capacitors was changed to the desired voltage and the charge held until exposure was initiated by dropping the voltage on the grid of the switch tube. The chief problem encountered had to do with gas in the switch tubes which allowed the charge to leak off the capacitors. You would have a youngster in position trying to take a chest on him, and you waited until he gasped for breath--then squeezed the button and nothing happened because the charge had leaked off the capacitor. So these things didn't last too long.

Another system developed for timing and switching high currents made use of the Thyratron which came into existence about the same time. This system was subject to frequent failure and generally unsatisfactory operation, and it dropped out of the picture.

The problem of timing and switching the high power and the poor resolution with the large focal spots available resulted in equipment design dropping to lower currents but at higher voltages. Such systems were the order of the day until multiple film cardiac studies became desirable as a result of some major advances in cardiac surgery. I think it was Helen Taussig and Si Blalock at Johns Hopkins who started this. In these procedures, there was then a use for a series of exposures made in very rapid succession. A debate quickly developed over the number of films required and the period of time over which these exposures had to be made to be of diagnostic value.

One school of thought held that a relatively small number of exposures made at spaced intervals was adequate. Another group felt that a great many films in a short period of time were required. Eventually, there developed evidence that the proponents of a large number of films in a short period of time were probably correct.

Eventually, it was pointed out that the large number of exposures which had to be made in the short period of time required very short exposure times and that the greater diagnostic value was due to the very short exposures rather than to the greater number of films. As a result of this, another attempt was made to develop stored energy, electronically switched equipment, the Dynapulse system. Such equipment was only partially successful and eventually disappeared from the market.

While all of this was going on, other so-called special procedures involving dye studies, rapid sequencing of exposures, and cine-radiography were receiving increased attention. Fortunately, about this time high-powered, solid state components became available as the result of the development of solid state devices using silicon, which gave them practically unlimited power-handling capacity. These devices can handle any power within reason that you want to deal with.

The first uses of these devices came in the replacement of high-vacuum rectifier tubes. In high-power systems making use of high-vacuum rectifiers, it had been necessary to provide some means of reducing the filament temperature of the rectifiers during stand-by periods. Otherwise, the filaments would evaporate in a short period of time. The availability of high-powered solid state rectifiers made it possible to dispense with such auxiliary filament systems, since the solid state devices had no filament.

There followed very quickly the use of some of these high-powered solid state devices in switching and timing systems. You could do switching with these things now and get away from the mechanical circuit-breakers that we had always had to use. It is the availability of these silicon solid state components that makes possible the high-powered, three-phase equipment presently available.

Along with all of this, of course, has gone the increased availability of three-phase power systems as new hospital facilities are built. Special transformer installations for x-ray departments always pose problems for the power company and the user. Such systems require transformers capable of supplying very high currents but for a very short period of time--fractional second exposure.

As a result, the power company had a considerable investment in the transformers, but the exposure times were so short that the number of kilowatt-hours for which the power company was paid never justified the capital investment in the transformer and distribution system. As a result, users usually paid what in some parts of the country was known as a demand charge based on the power that was available rather than the power that was used. A typical charge was $1.00 per kilowatt per month--a demand charge.

In our part of the country, the charge was called an "excess minimum" charge and was usually a percentage of the cost of the transformer installation, having originally been negotiated with the public utilities commission in that State. A typical excess minimum charge was 1.5 percent of the cost of the transformer installation.

In our part of the country an installation involving a single 75 KVA transformer would have an excess minimum charge of 1.5 percent of an investment of about $650, which would amount to roughly $10 a month. If the transformer system was for a 750 milliampere, three-phase system, the excess minimum charge could go to between $35 and $40 a month.

The electric supply for most new hospital facilities presently makes use of a transformer system capable of supplying all the hospital power needs from a single three-phase transformer installation and so the stand-by charges have disappeared, and the cost of this high-powered equipment on a monthly basis has gone down.

As the cost of wiring materials and labor has gone up over the years, the cost of wiring for single-phase and three-phase equipment is nowadays just about the same. The three-phase equipment for a given power loading may require another wire and some more elaborate circuit breakers, but since this wire is smaller, the labor charges have become the overriding factor.

The problem of large conductors for long runs from the transformer to the equipment has been reduced by the use of 440 volt distribution systems.

Now, these were not common in hospitals until a few years ago, although they were quite common in industrial installations. But in modern hospital planning under good electrical engineering conditions, you will find 440 distribution systems which takes care of wire size.

When all these factors are coupled with an increased demand on the part of radiologists for higher power--that is, more tube current--it is not difficult to understand the increased use of high-powered, three-phase systems. And it does not require a set of new tea leaves to predict that this demand will continue for some time.

Of course, along with the development of satisfactory high-powered generator equipment has gone the development of x-ray tubes capable of handling high-powered exposures, new metallurgical technology--the rhenium backing business--and operation of rotors at higher speeds provide tubes having smaller focal spots and capable of handling much higher powered loadings.

Whether there is a continuation in the direction of operation at still higher tube currents remains to be seen. There are always those who want something bigger and better than the Joneses have, and this coupled with industrial competition could lead to continued development in this direction.

There is some question in the minds of many of us whether it is needed, but you don't put a ceiling on these things very readily.

A major development for some years has been going on in the field of image amplifiers for use in fluoroscopic and cine-radiographic work. The first trend was to the development of large multi-purpose image systems. The cost of such systems reduced their general availability.

In the last few years, the tendency has been to small image tubes with television rather than direct viewing and a resulting decrease in cost. So more and more people can own these systems. As in any field involving a new development, progress was slow and it has been costly. With experience, the development pace accelerates, designs incorporate added experience, and costs come down resulting in more users being able to use these more sophisticated systems.

Then, too, such development goes through stages where a number of types of systems must be provided because nobody is quite sure what is needed for this application. Eventually, a point is reached where a few basic designs will handle most of the needs. One has the feeling that the image amplifier has just about reached the plateau stage. Although there are some possible new concepts, such as the use of fiber optics to replace the costly lens system, one suspects that in general changes will be made more slowly and will be less dramatic.

The first image amplifier systems made use of an x-ray tube under the table with the receptor and image system above the table. Several pieces of special procedure equipment have come on the market using what some of us call an "inverted" fluoroscopic system wherein the x-ray tube is above the table with the image system below the table.

Where such systems are used with television readout with a secondary barrier between the tube and the operator, there is no unusual protection problem. But in any system of this kind where there is no protective barrier between the operator and the image set, special attention must be paid to personnel exposure especially in those systems that make use of an open table structure.

You see that many of these things do not have a closed table structure. And this leads to forward scatter from the patient, striking the floor. The open tables have always given us problems because of the scattered radiation all over the room.

An open table provides little in the way of shielding from scattered radiation originating in the patient and scattered in a forward direction toward the floor. So you may want to take a look at these things.

Systems of this kind are found in some of the therapy simulators. Don't just restrict your attention to the diagnostic rooms because some of the therapy simulators make use of this kind of system. And if the therapist insists on being in the room with the simulator and the patient as the planning is being done, then you are going to have to take a look at the protective clothing and the things which they have to wear under such conditions.

Another such special situation arises in the use of mobile image amplifier systems that we saw here a little while before for surgical procedures. The very nature of their use prevents the use of secondary barriers other than protective clothing and special consideration and guidance may be the role of the hospital physicist or the radiation inspector.

One of the things that you find is that when you go into a hip pinning job, you cannot continue to think in terms of 10-inch minimum distance between the focal spot of the tube and the skin of the patient. They just can't do hip pinning under those conditions. And you will find fluoroscopic distances down to six to eight inches.

Every such installation poses special problems associated with the method of use in that particular installation because the use is generally peculiar and unique to a given installation.

A great deal of emphasis today is on better image recording systems, in the way of improved TV monitors, better methods of filming and tape recording which still has a ways to go.

Earlier in this discussion, the development of high-powered mobile equipment was mentioned. As better power facilities became available in the hospital rooms and wards, high-powered equipment using conventional transformer systems became available. These got up to 300 milliamperes in some cases. More recently, other types of systems have become available. One such system is the capacitor discharge system that I mentioned earlier where a bank of capacitors is charged at low current from a low-power high-voltage supply system and the accumulated charge used to energize the x-ray tube. Such systems are not new for they were originally developed in the middle 1930's for high-powered chest radiography.

All of the major manufacturers in the United States at that time made such equipment. It did not prove popular because of the appearance of the films which results from an exposure that starts at peak voltage and continues at decreased voltage until the photons produced no longer reach the film. If you have looked at these capacitor discharge films, having seen one, you can recognize one any time you see one.

Although the major manufacturers dropped this heavy high-powered equipment after very few years, the general concept has been kept alive by one small company who used a cold emission tube energized by a charged capacitor. That is the flash x-ray system that we have heard about. And this has probably led to considerable misunderstanding on the part of people where you don't define the words. You say "flash radiography," and everybody assumes that the patient is getting very little exposure because, after all, this is a flash exposure.

The facts of the matter are that the film can't tell what kind of a system was used to produce the photon. And the current in these flash systems may be of the order of amperes not milliamperes. So if you measure the exposure not in terms of milliseconds and nanoseconds, but measured in terms of milliroentgens or rads or rems or whatever you want to put in it, there is no difference between that and the conventional type of machinery.

I did flash radiography in 1923 or 1924 with a 5-plate, 36-inch diameter static machine. Those big static machines were all supplied with a set of capacitors which you could charge up. It was not uncommon for us who were teaching with these things to change the capacitors and then put the spheres together to make a contact with a gas x-ray tube. And we got flash x-ray exposure. So there is nothing new even in that.

The recent development in capacitor discharge units has been in the way of lower-powered equipment for bedside radiography. Whether it becomes generally accepted this time around, I can't even guess.

If you have studied the history of x-ray equipment, you know that Roentgen used an induction coil operated from a battery to produce the high voltage necessary for the operation of his tube. The induction coils required a make-and-break mechanism for the operation of the coil from a direct current supply.

For many years, the coil and the static machine competed as the source of high voltage. And the static machine stayed in as long as it did only because it didn't have to have a make-and-break mechanism. Larger and more powerful coils could be built. Vulcan built some whopping big ones, but the problem was always in the interruptors used to make and break the DC supply. The magnetic vibrator was not satisfactory at high powers because the points burned away.

One of the systems developed for high power was the Wehnelt, or electrolytic interruptor. Although it permitted the use of greater currents in the coil, it was a messy business, at best, requiring a lot of maintenance.

Another system made use of a motor-driven turbine with mercury as the contact medium. This, too, required considerable maintenance due to the oxidation of the mercury.

By 1905 alternating current technology was well understood by a few individuals. Fortunately for us, a fellow by the name of Clyde Snook was one of them. He developed the alternating current transformer whereby the use of alternating current into the primary did away with the need for any breaker or interruptor system. Such transformers were originally called "interruptorless" transformers. They were still called that when I got involved with this business. The result was that the x-ray tube and not the high-voltage system became the limiting factor and has been since Snook developed the AC transformer.

The availability of solid state silicon switching components has recently led to a new type of bedside or mobile unit wherein the old interruptors of one kind or another are replaced by silicon solid state switch units. The solid state switching devices are combined with nickel cadmium storage batteries which can be charged from any wall plug. In use, the switch tubes provide a square wave 500 Hertz AC supply to the primary of a conventional transformer system using silicon rectifiers.

The equipment incorporates a second inverter system providing alternating current to operating anode tube and the filament of that tube. The result is a mobile unit for operation at up to 110 kVp and currents up to 100 milliamperes. Since no external power is required during operation, there is no power cable which has always been a nuisance to the technologists using such equipment at bedside.

Storage battery operation provides a very stable voltage and so mobile or bedside films are no longer at the mercy of variations in voltage of a power line that goes to a wall plug.

The weight of the apparatus continues to be a problem. With any high-powered mobile equipment, the matter of mobility is an increasing problem as more hospitals put carpeting in the wards and in the corridors.

For some years a major problem in any large x-ray department has been that of information retrieval--that is, making past films and examination records quickly available for comparison with current radiographs and findings. Some progress has been made in this direction through the use of automated film retrieval systems, but there is still a long way to go. It may be that if magnetic bubble technology improves, better information storage systems will become smaller, less expensive; hence, more readily available to more people. If so, this new technology could change the whole information retrieval business.

Another area that will surely receive considerable attention is that of image transmission. The automatic processor which makes possible a small automated processing facility no longer requires that all x-ray equipment be centered around a large central processing facility. X-ray equipment can be installed with an automatic processing unit in areas remote from the central radiological operation.

For maximum usefulness, it is desirable to be able to transmit radiographic images back to some central area where an evaluation can be made without the necessity of either keeping a radiologist available at the remote installation or making a trip to look at the film.

A good system of image transmission could also be extensively used in permitting small hospitals in remote areas to have a diagnosis made by a radiologist a long ways off. It is true that from time to time demonstrations of such systems have been made, but generally in every case as far as I know, this has required a coaxial line which costs lots of money.

The great need is for an image system that can be used with conventional telephone lines. Presently, the use of existing telephone facilities is reported as providing poor image quality at the receiving end.

The only one I know that has kept in operation for any considerable period of time was in Nebraska. And perhaps the people from Nebraska can tell us later whether or not they still have it running.

No speaker addressing himself to the future dares ignore the computer. As they become smaller and less costly, they may come to play some part in the production of diagnostic information. It is not difficult to imagine a computerized radiographic control system whereby certain information as to patient size and contour is fed into a computer to set up all the exposure factors.

If we had available the talent and the money that we pour into a single space program, we could probably devise a system with a conveyor system on which patients were placed end to end, carried past an x-ray tube, data accumulated on a receptor, the result evaluated, the diagnosis and the image put on videotape, all information, including the significant gonadal dose fed into a national repository for health information. Since development appropriations would require approval of some responsible fiscal body or individual, I suspect there would be added an automated system for Medicare billing, including renegotiation procedures.

If I seem to have fallen off the log, it might be well to remember that when I started in this business, there was no shock-proof equipment except one type of dental unit, no tilting table that had a Bucky diaphragm on it, the maximum tube current was 100 mA on a 5 mm focal span, exposures were 10 to 20 times what they are today, 1/10 second timers were hard to come by and ureliable, luminescence of fluoroscopic screens was 1/10 what it is today and gonadal exposure was not a subject for public discussion.

Thank you.

DR. KINSMAN: Thank you very much, Dale.

Any questions for Dr. Trout?

We will proceed to hear about the management of all these records that Dale is going to compile. I am sure that records are a big part of this whole radiation control area. I think the records themselves are quite insufficient for us to acquire a lot of data that we need.

So, John W. Shaver from North Carolina State Board of Health is going to entertain us on the subject of records management.

John.

RECORDS MANAGEMENT

John W. Shaver[1]

Thank you, Dr. Kinsman.

With the ocean sitting so close by and the seats starting to get hard this late in the afternoon, I will try not to detain you too long. But I would like to share with you a recordkeeping system that we have developed in North Carolina for our x-ray control program.

I plan to discuss the registration procedures and inspection procedures used in North Carolina from a recordkeeping point of view--namely the documents involved and the filing systems used. First, I would like to discuss the documents, where they are filed, and then tie this in to the use made of these records.

(See Figure 1.)

This is the application form that we use. It is similar to forms used by other States in that it requests the name and address of the user, the type of equipment being registered, and the manufacturer, model number, rated mA and kVp of the machine.

I would like to digress just a minute from records management and discuss one particular item on this form. The bottom line requests the person's qualifications in brief. It is referring to the person charged with responsibility of radiation protection for the machine that is being registered. Our regulations, as many other State regulations, do give some guidance regarding acceptable qualifications.

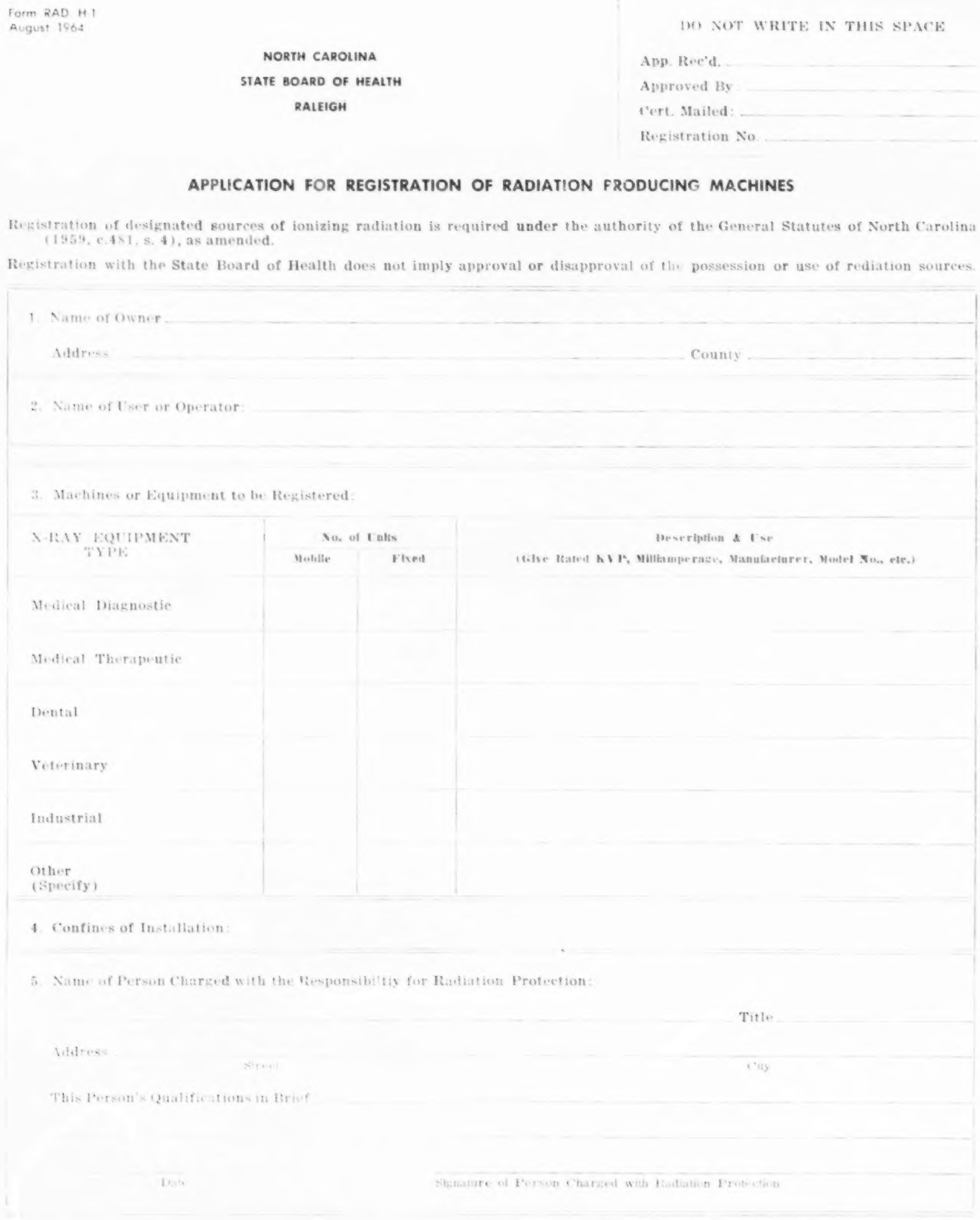
Our regulations state (1) that the individual shall be qualified by training and experience concerning all hazards and precautions involved in handling the machines for which he is responsible; (2) that he shall recommend a detailed program of radiation safety for effective compliance with the regulations; (3) that the individual shall give instructions concerning hazards and safety practices to persons who may be exposed to radiation from his machine; and, (4) that he make surveys and carry on other procedures as required by the regulations.

In North Carolina, as in many other States, we are primarily examining the person's credentials. That is, if he is a licensed practitioner, we are accepting that in lieu of the above. We are inconsistent in that we require, in most cases, the submission of detailed radiation protection programs by industrial registrants.

---

[1] Radiation Protection Program, North Carolina State Board of Health.

Figure 1



Form RAD H-1
August 1964

NORTH CAROLINA
STATE BOARD OF HEALTH
RALEIGH

DO NOT WRITE IN THIS SPACE

App. Rec'd. __________
Approved By: __________
Cert. Mailed: __________
Registration No. __________

APPLICATION FOR REGISTRATION OF RADIATION PRODUCING MACHINES

Registration of designated sources of ionizing radiation is required under the authority of the General Statutes of North Carolina (1959, c.481, s. 4), as amended.

Registration with the State Board of Health does not imply approval or disapproval of the possession or use of rediation sources.

1. Name of Owner __________
Address __________ County __________

2. Name of User or Operator: __________

3. Machines or Equipment to be Registered:

X-RAY EQUIPMENT TYPE	No. of Units		Description & Use (Give Rated KVP, Milliamperage, Manufacturer, Model No., etc.)
	Mobile	Fixed	
Medical Diagnostic			
Medical Therapeutic			
Dental			
Veterinary			
Industrial			
Other (Specify)			

4. Confines of Installation:

5. Name of Person Charged with the Responsibiltiy for Radiation Protection:

__________ Title __________

Address __________ Street __________ City

This Person's Qualifications in Brief __________

__________ Date

__________ Signature of Person Charged with Radiation Protection

As I said, this is somewhat digressing. The point is we should look at our procedures to determine that we are requiring sufficient information to adequately process an application.

May I have the next slide please.

(See Figure 2.)

This is the "Notice of Registration" form which contains the same information shown on the application form. Once this form is completed, the applicant is registered. There are three copies of this form.

(See Figure 3.)

The "Coding Record" is the heart of our recordkeeping system, and, again, contains the same information that is on the other two forms. This is the third and final document used in our registration procedure. However, there are a couple comments I would like to make about this form.

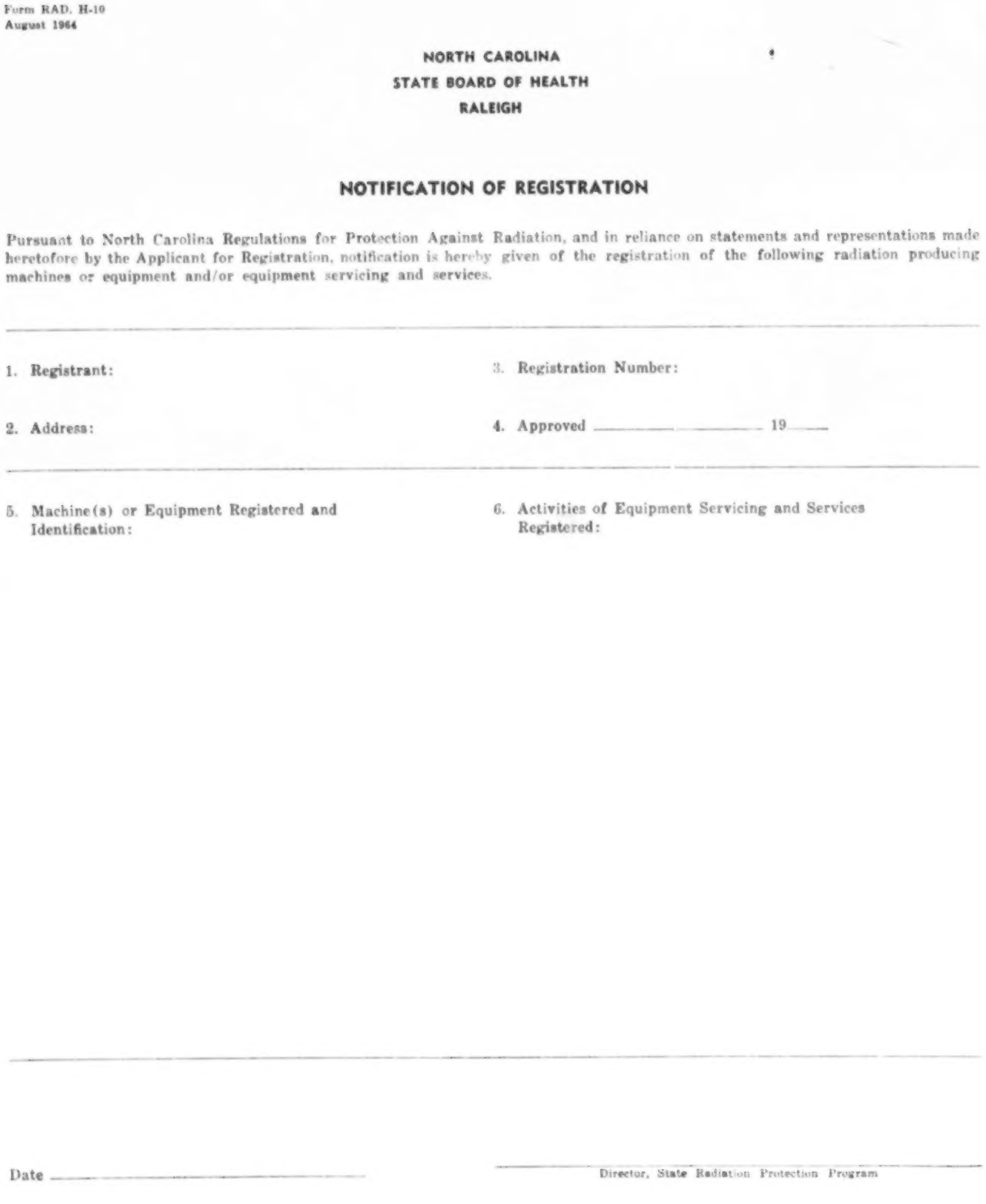
Item 8, which is the type of practice or use, indicates whether the registrant is a chiropractor, veterinarian, dentist, physician, etc. Item 9, which is the type of facility, refers to whether the facility is an educational institution, hospital, private practice, clinic, etc.

We have added some other items to this form that do not appear in this slide, such as whether or not the facility has a fluoroscope. In many cases one is unable to tell from the application if the machine is a fluoroscope. So we have modified the form to specifically request that information.

We are also coding the status of the facility as to being active, terminated or stored. The stored item typically refers to a situation where the physician or dentist has died and his wife has the machine in a garage. The registration is not terminated but the machine is stored to remind us to periodically recheck its status. We have about 40 machines in this category.

There is one other item that we are coding that does not appear on this printed form. This is whether or not the facility was inspected prior to July 1, 1967. This is peculiar to our program in that we began utilizing the U. S. Public Health Service survey inspection forms on that date. However, we also wanted to know which facilities had been inspected prior to this date to indicate to us that no punch card data is available for these particular facilities. Before explaining our filing system, there is one other item I would like to discuss.

Figure 2



Form RAD. H-10
August 1964

NORTH CAROLINA
STATE BOARD OF HEALTH
RALEIGH

NOTIFICATION OF REGISTRATION

Pursuant to North Carolina Regulations for Protection Against Radiation, and in reliance on statements and representations made heretofore by the Applicant for Registration, notification is hereby given of the registration of the following radiation producing machines or equipment and/or equipment servicing and services.

1. Registrant:

2. Address:

3. Registration Number:

4. Approved ________________ 19____

5. Machine(s) or Equipment Registered and Identification:

6. Activities of Equipment Servicing and Services Registered:

Date ____________________

____
Director, State Radiation Protection Program

Figure 3

NORTH CAROLINA STATE BOARD OF HEALTH
RADIOLOGICAL HEALTH SECTION

Coding Record for Registration
of
Radiation Producing Machines

Item No.

1. Registration Number

1	2	3	4	5	6

2. County Code

7	8

3. Last Name, First Name and Middle Name

9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28

4. Title

29

5. Address: Street No. & Name

30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

6. City and State

51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67

7. Zip Code

68	69	70	71	72

8. Type of Use or Practice

73

9. Type of Facility

74

10. No. of Machines

75

Figure 4. North Carolina X-ray Protection Program

Category Classifications

P	Physicians	L	Health Departments
D	Dentists	A	Clinics & Educational Institutions
V	Veterinarians	S	Services
C	Chiropractors	I	Industries
H	Podiatrists	M	Medical Care

This is the classification system that we are using. There is only one thing unique about this system. You will notice that there is no hospital classification but there is a classification called Medical Care. This is a peculiarity of our program. The x-ray equipment used in hospitals in North Carolina or used in any facility receiving Hill-Burton funds is under the jurisdiction of the North Carolina Medical Care Commission. Thus, the M codes are in effect our voluntary registrants.

Figure 5.

Registrant's Folder

Field Folder

Punch Cards

These are the three filing systems that we are using in our registration procedures. The registrant's folder contains the application, the notice of application, the coding record and all the survey forms and correspondence pertaining to the registrant.

The inspector's field folder contains one copy of the notification form. We have 100 counties in North Carolina and one folder for each county. We have this file so the inspector can compare the equipment he finds in the field with that registered.

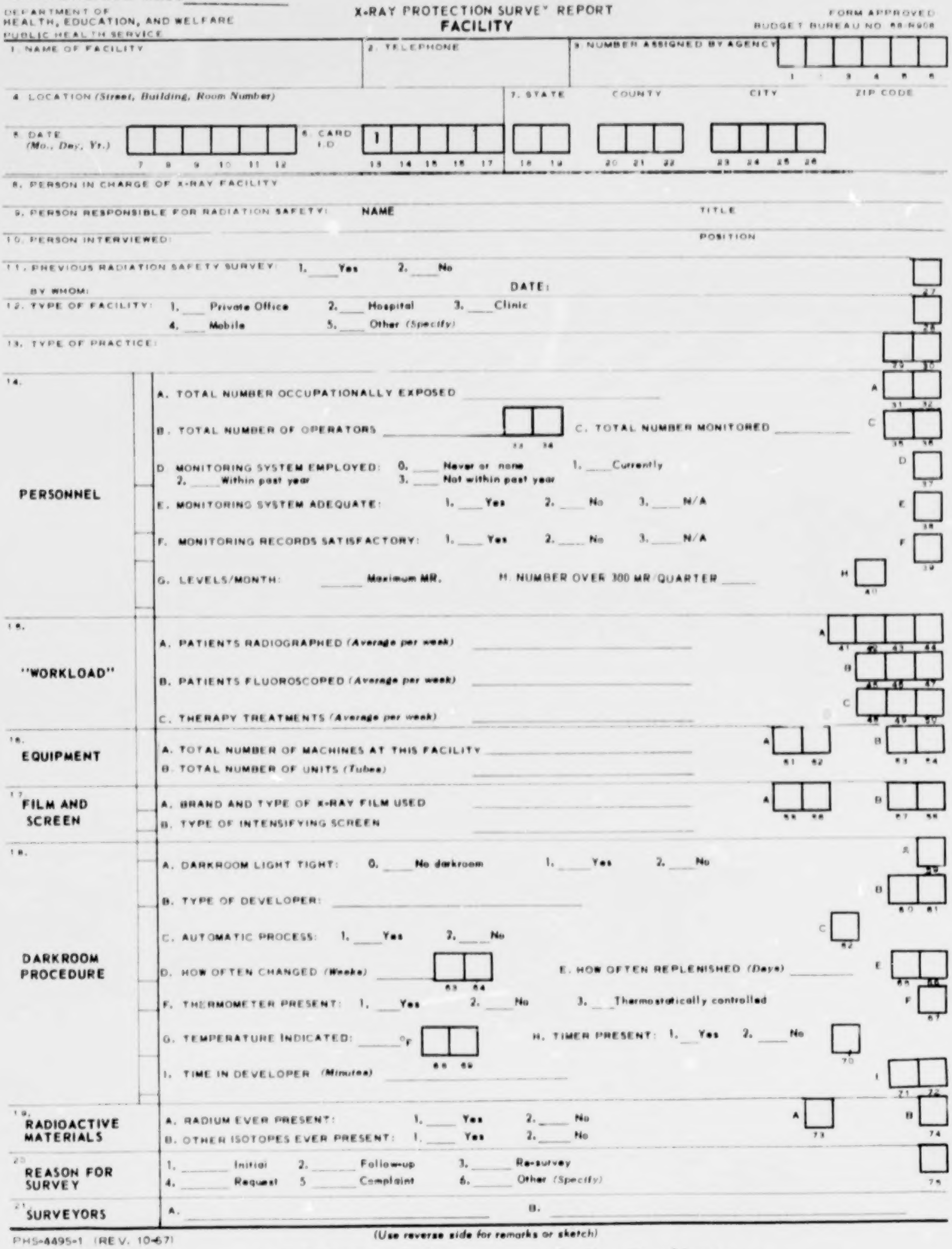
The third file is a registrant's punch card file. These are the punch cards from the coding record shown earlier. Next, I would like to discuss the documents used in our inspection procedures.

(See Figure 6.)

This is the Public Health Service X-ray Survey Facility Form. I have shown this is to point out the modification we have made. One item at the very bottom has been added to indicate the state of compliance. This is a 4-code system with code 1 indicating compliance before, code 2 compliance by inspector, code 3 noncompliance and code 4 compliance by communication. Thus, if after the conclusion of the inspector's survey there are no items

Figure 6

Installation Date__________



DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE

X-RAY PROTECTION SURVEY REPORT
FACILITY

FORM APPROVED
BUDGET BUREAU NO. 68-R908

1. NAME OF FACILITY
2. TELEPHONE
3. NUMBER ASSIGNED BY AGENCY ☐☐☐☐☐☐ (1–6)
4. LOCATION *(Street, Building, Room Number)*
7. STATE ☐☐ (18 19) COUNTY ☐☐☐ (20 21 22) CITY ☐☐☐☐ (23 24 25 26) ZIP CODE
5. DATE *(Mo., Day, Yr.)* ☐☐☐☐☐☐ (7 8 9 10 11 12)
6. CARD I.D. 1 ☐☐☐☐ (13 14 15 16 17)
8. PERSON IN CHARGE OF X-RAY FACILITY
9. PERSON RESPONSIBLE FOR RADIATION SAFETY: NAME TITLE
10. PERSON INTERVIEWED: POSITION
11. PREVIOUS RADIATION SAFETY SURVEY: 1. ___ Yes 2. ___ No ☐ (27)
BY WHOM: DATE:
12. TYPE OF FACILITY: 1. ___ Private Office 2. ___ Hospital 3. ___ Clinic ☐ (28)
4. ___ Mobile 5. ___ Other *(Specify)*
13. TYPE OF PRACTICE: ☐☐ (29 30)

14. **PERSONNEL**
A. TOTAL NUMBER OCCUPATIONALLY EXPOSED ______ A ☐☐ (31 32)
B. TOTAL NUMBER OF OPERATORS ______ ☐☐ (33 34) C. TOTAL NUMBER MONITORED ______ C ☐☐ (35 36)
D. MONITORING SYSTEM EMPLOYED: 0. ___ Never or none 1. ___ Currently 2. ___ Within past year 3. ___ Not within past year D ☐ (37)
E. MONITORING SYSTEM ADEQUATE: 1. ___ Yes 2. ___ No 3. ___ N/A E ☐ (38)
F. MONITORING RECORDS SATISFACTORY: 1. ___ Yes 2. ___ No 3. ___ N/A F ☐ (39)
G. LEVELS/MONTH: ______ Maximum MR. H. NUMBER OVER 300 MR/QUARTER ______ H ☐ (40)

15. **"WORKLOAD"**
A. PATIENTS RADIOGRAPHED *(Average per week)* ______ A ☐☐☐☐ (41 42 43 44)
B. PATIENTS FLUOROSCOPED *(Average per week)* ______ B ☐☐☐ (45 46 47)
C. THERAPY TREATMENTS *(Average per week)* ______ C ☐☐☐ (48 49 50)

16. **EQUIPMENT**
A. TOTAL NUMBER OF MACHINES AT THIS FACILITY ______ A ☐☐ (51 52)
B. TOTAL NUMBER OF UNITS *(Tubes)* ______ B ☐☐ (53 54)

17. **FILM AND SCREEN**
A. BRAND AND TYPE OF X-RAY FILM USED ______ A ☐☐ (55 56)
B. TYPE OF INTENSIFYING SCREEN ______ B ☐☐ (57 58)

18. **DARKROOM PROCEDURE**
A. DARKROOM LIGHT TIGHT: 0. ___ No darkroom 1. ___ Yes 2. ___ No A ☐ (59)
B. TYPE OF DEVELOPER: ______ B ☐☐ (60 61)
C. AUTOMATIC PROCESS: 1. ___ Yes 2. ___ No C ☐ (62)
D. HOW OFTEN CHANGED *(Weeks)* ______ ☐☐ (63 64) E. HOW OFTEN REPLENISHED *(Days)* ______ E ☐☐ (65 66)
F. THERMOMETER PRESENT: 1. ___ Yes 2. ___ No 3. ___ Thermostatically controlled F ☐ (67)
G. TEMPERATURE INDICATED: ______ °F ☐☐ (68 69) H. TIMER PRESENT: 1. ___ Yes 2. ___ No ☐ (70)
I. TIME IN DEVELOPER *(Minutes)* ______ I ☐☐ (71 72)

19. **RADIOACTIVE MATERIALS**
A. RADIUM EVER PRESENT: 1. ___ Yes 2. ___ No A ☐ (73)
B. OTHER ISOTOPES EVER PRESENT: 1. ___ Yes 2. ___ No B ☐ (74)

20. **REASON FOR SURVEY**
1. ______ Initial 2. ______ Follow-up 3. ______ Re-survey ☐ (75)
4. ______ Request 5 ______ Complaint 6. ______ Other *(Specify)*

21. **SURVEYORS**
A. ______ B. ______

PHS-4495-1 (REV. 10-67)

(Use reverse side for remarks or sketch)

1. Compliance Before
2. Compliance by Surveyor
3. Non Compliance
4. Compliance by Communication

of noncompliance noted, the facility is coded as compliance before. If during the inspection the inspector brings the facility into compliance, it would be coded compliance by inspector. If the facility was found in noncompliance, these items would be reviewed with the registrant. He would be advised that he will receive a letter citing the items and requesting that he respond within 30 days as to the corrective action that has been taken. When he responds, and indicates that he has corrected all the items of noncompliance, his facility form would then be coded compliance by communication.

We have added one other item at the top of this form entitled "Date of Installation," which was added simply to remind us to ask this question. We are also using other U. S. Public Health Service X-ray Survey forms including the radiographic, fluoroscopic and therapeutic forms. I am not going through these forms since I think most of you are familiar with them. However, we are using a different dental form.

(See Figures 7 and 8.)

This form, I believe, was developed by the Kentucky Program. If any State would like copies, we would be more than happy to supply them.

This is the back of the dental survey form. You will notice that we are again coding the compliance item on this form. These survey forms make up our source documents for the inspection results. These are punched into cards and filed in the cabinet in our office. This is a special cabinet designed to accept the punched cards which are filed by registration number.

Next, let me attempt to tie some of these items together. You have now seen the documents and the filing systems we have. Next, I would like to describe the equipment that we are using in data processing.

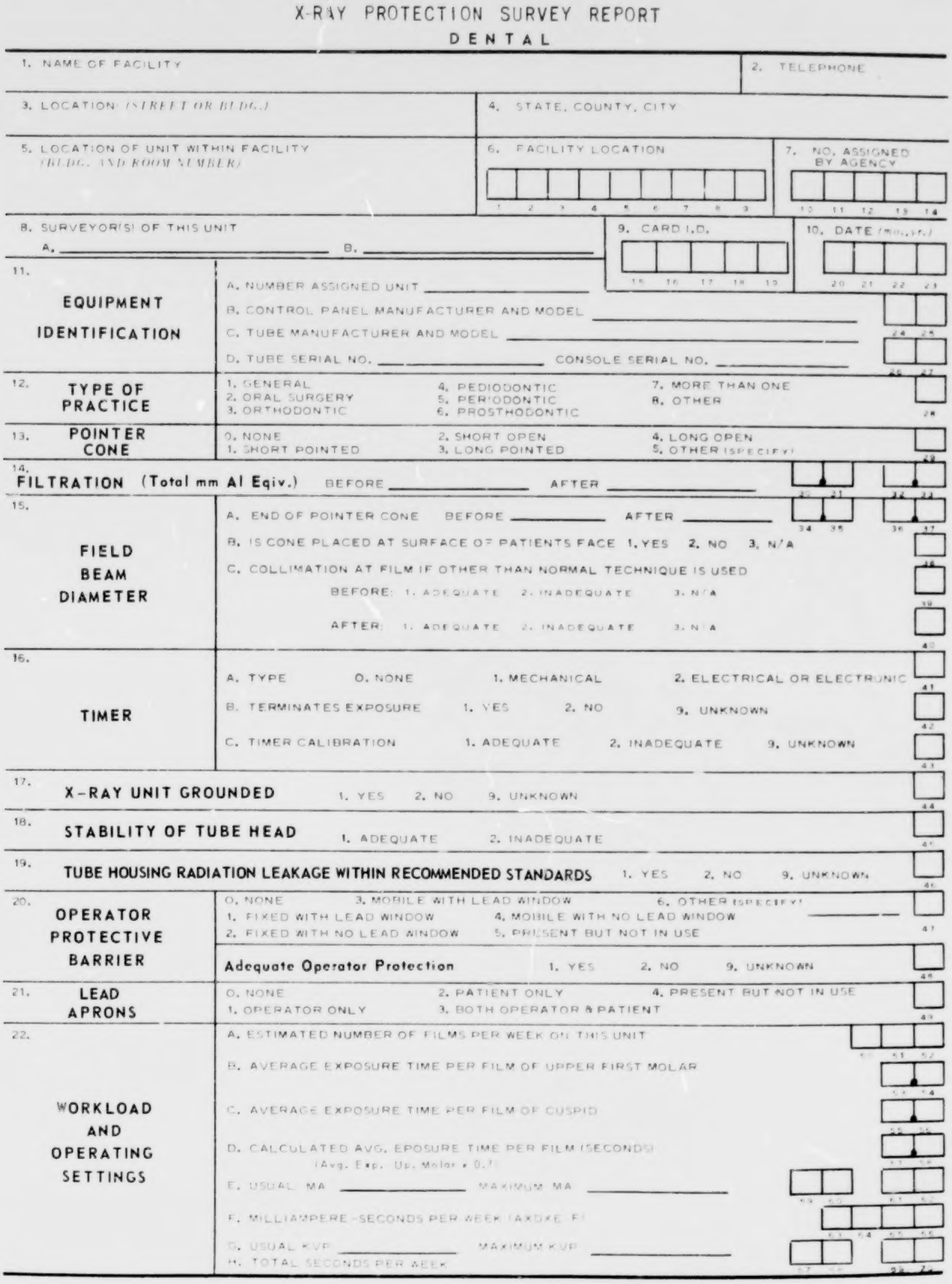
We have found that simple tabulating equipment is sufficient for the scope of our program at the present time. We are using a key punch machine, a verifying machine, a card sorter, a collator and an accounting machine to list our reports.

The reason we are using this equipment instead of a computer, is primarily for three reasons (1) the equipment is convieniently located to us, (2) we can operate it ourselves, meaning our own staff and we are permitted to operate it at our own convenience, and (3) our volume is quite low.

We have approximately 2500 facilities registered and our card volume is such that it doesn't require an extensive amount of time to run the cards through a sorter. Thus, we can prepare most of the reports ourselves.

If the volume should increase to the point that it becomes very time consuming to continue to use this type of equipment, we can very easily

Figure 7



X-RAY PROTECTION SURVEY REPORT

DENTAL

1. NAME OF FACILITY

2. TELEPHONE

3. LOCATION *(STREET OR BLDG.)*

4. STATE, COUNTY, CITY

5. LOCATION OF UNIT WITHIN FACILITY *(BLDG. AND ROOM NUMBER)*

6. FACILITY LOCATION ☐☐☐☐☐☐☐☐☐

7. NO. ASSIGNED BY AGENCY ☐☐☐☐☐

8. SURVEYOR(S) OF THIS UNIT A. ____________ B. ____________

9. CARD I.D. ☐☐☐☐☐

10. DATE (mo., yr.) ☐☐☐☐

11. **EQUIPMENT IDENTIFICATION**
A. NUMBER ASSIGNED UNIT ____________
B. CONTROL PANEL MANUFACTURER AND MODEL ____________ ☐☐
C. TUBE MANUFACTURER AND MODEL ____________
D. TUBE SERIAL NO. ____________ CONSOLE SERIAL NO. ____________ ☐☐

12. **TYPE OF PRACTICE** ☐
1. GENERAL
2. ORAL SURGERY
3. ORTHODONTIC
4. PEDIODONTIC
5. PERIODONTIC
6. PROSTHODONTIC
7. MORE THAN ONE
8. OTHER

13. **POINTER CONE** ☐
0. NONE
1. SHORT POINTED
2. SHORT OPEN
3. LONG POINTED
4. LONG OPEN
5. OTHER (SPECIFY)

14. **FILTRATION (Total mm Al Eqiv.)** BEFORE ____________ AFTER ____________ ☐.☐ ☐.☐

15. **FIELD BEAM DIAMETER**
A. END OF POINTER CONE BEFORE ____________ AFTER ____________ ☐.☐ ☐.☐
B. IS CONE PLACED AT SURFACE OF PATIENTS FACE 1. YES 2. NO 3. N/A ☐
C. COLLIMATION AT FILM IF OTHER THAN NORMAL TECHNIQUE IS USED
BEFORE: 1. ADEQUATE 2. INADEQUATE 3. N/A ☐
AFTER: 1. ADEQUATE 2. INADEQUATE 3. N/A ☐

16. **TIMER**
A. TYPE 0. NONE 1. MECHANICAL 2. ELECTRICAL OR ELECTRONIC ☐
B. TERMINATES EXPOSURE 1. YES 2. NO 9. UNKNOWN ☐
C. TIMER CALIBRATION 1. ADEQUATE 2. INADEQUATE 9. UNKNOWN ☐

17. **X-RAY UNIT GROUNDED** 1. YES 2. NO 9. UNKNOWN ☐

18. **STABILITY OF TUBE HEAD** 1. ADEQUATE 2. INADEQUATE ☐

19. **TUBE HOUSING RADIATION LEAKAGE WITHIN RECOMMENDED STANDARDS** 1. YES 2. NO 9. UNKNOWN ☐

20. **OPERATOR PROTECTIVE BARRIER** ☐
0. NONE
1. FIXED WITH LEAD WINDOW
2. FIXED WITH NO LEAD WINDOW
3. MOBILE WITH LEAD WINDOW
4. MOBILE WITH NO LEAD WINDOW
5. PRESENT BUT NOT IN USE
6. OTHER (SPECIFY) ____________

Adequate Operator Protection 1. YES 2. NO 9. UNKNOWN ☐

21. **LEAD APRONS** ☐
0. NONE
1. OPERATOR ONLY
2. PATIENT ONLY
3. BOTH OPERATOR & PATIENT
4. PRESENT BUT NOT IN USE

22. **WORKLOAD AND OPERATING SETTINGS**
A. ESTIMATED NUMBER OF FILMS PER WEEK ON THIS UNIT ☐☐☐
B. AVERAGE EXPOSURE TIME PER FILM OF UPPER FIRST MOLAR ☐.☐
C. AVERAGE EXPOSURE TIME PER FILM OF CUSPID ☐.☐
D. CALCULATED AVG. EPOSURE TIME PER FILM (SECONDS) (Avg. Exp. Up. Molar × 0.7) ☐.☐
E. USUAL MA ____________ MAXIMUM MA ____________ ☐☐ ☐☐
F. MILLIAMPERE-SECONDS PER WEEK (AXDXE F) ☐☐☐☐
G. USUAL KVP ____________ MAXIMUM KVP ____________ ☐☐ ☐☐
H. TOTAL SECONDS PER WEEK

Figure 8

23. **FILM USED**

A. BITEWING: MANUFACTURER ____ TYPE OR CODE ____ ☐☐ 71 72

B. PERIAPICAL: MANUFACTURER ____ TYPE OR CODE ____ ☐☐ 73 74

C. OTHER: MANUFACTURER ____ TYPE OR CODE ____ ☐☐ 75 76

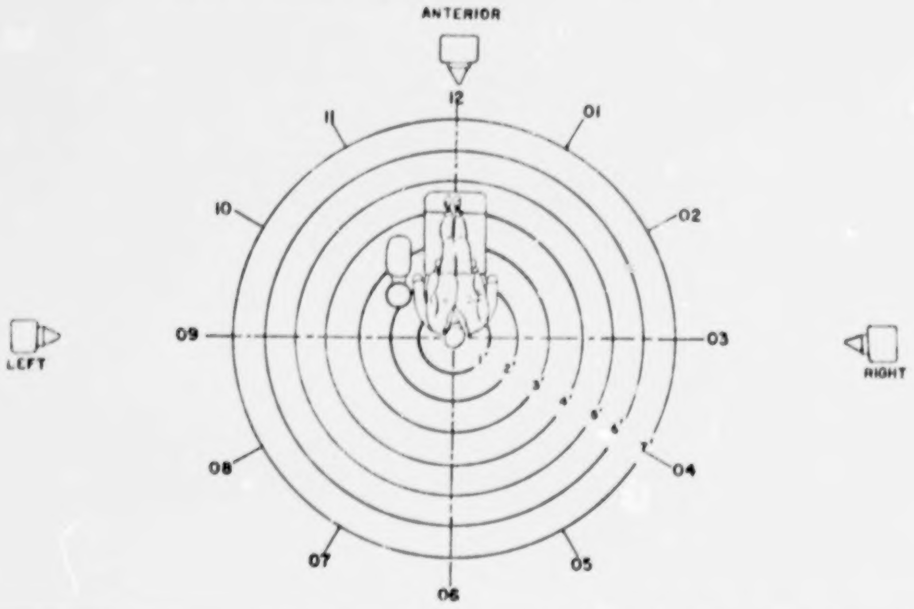
DESCRIBE ____

24. **SURVEY VISITS AT THIS INSTALLATION** (NUMBER) ____ ☐☐ 77 78

25. **STATUS OF MACHINE:** 1. ACTIVE 2. INACTIVE ☐ 79

26. **COMPLIANCE:** 1. COMPLIANCE BEFORE 2. COMPLIANCE BY SURVEYOR 3. NON-COMPLIANCE 4. COMPLIANCE BY COMMUNICATION ☐ 80

27. **OCCUPATIONAL EXPOSURE:** SCATTER RADIATION



	DIRECTION	DISTANCE	EXPOSURE	AT NEW POSITION
A. LEFT BITEWING EXPOSURE	____	____	____ mr/hr	____ mr/hr
B. ANTERIOR LOWER PERIAPICAL	____	____	____ mr/hr	____ mr/hr
C. RIGHT BITEWING EXPOSURE	____	____	____ mr/hr	____ mr/hr

28. **STRUCTURAL BARRIERS:** 1. ADEQUATE ____ 2. INADEQUATE ____

29. **ESTIMATED OPERATOR'S EXPOSURE:**

(22.A.) (22.D.) (AVERAGE EXPOSURE-MR/HR) (0.015) = ____ MR/YEAR

30. **COMMENTS**

31. MACHINE ADEQUATE DATE: ____

N. C. STATE BOARD OF HEALTH

Rad H-11

go to a computer. For example, our Environmental Surveillance Program requires extensive use of a computer. We have about seven or eight environmental surveillance computer programs that we can routinely run. It would be quite easy for us to put our x-ray system on a computer. Nevertheless, I think it could be said that we are using very simple antiquated equipment in the x-ray program and you will find that it is quite useful.

Figure 9.

1. Alphabetic by Facility Name
2. Alphabetic by Category
3. Registration Number
4. Alphabetic by County
5. Inspected Since 1 July 1967 (Alphabetic by Compliance)
6. Inspected Before 1 July 1967 (Alphabetic by Category)
7. Never Inspected (Alphabetic by County)
8. Medical Care Facilities
9. Stored Machines
10. Terminations
11. Fluoroscopes

This is a list of the routine reports that we have run approximately every six months. You will note there are a total of 11 reports. One might ask, "Why have so many reports run?" I point out that these reports are only groupings of the data that was contained on the original application form. Nine of the reports are obtained by sorting the registration cards into different categories that we feel are quite useful for our inspector to have in the field.

The first report is simply a gross alphabetical listing of our facilities by facility name. The second report is a grouping of all our facilities by the category classifications that were described earlier. The third report is a grouping by the registration number. For example, a D code is used for dentists, thus the first dental registrant would be D00001, the second dental registrant D00002. This listing is quite useful to the people who assign the registration numbers. When we first went to this system we were surprised to discover how many facilities had the same registration number. It is not a real important item. However, one would not particularly care to have 40 or 50 facilities sharing the same registration number.

The next report is an alphabetical listing of all our facilities sorted by county. Each sheet lists the registrants in that county.

The next listing represents the facilities that were inspected before July 1, 1967. To run this particular report, we sort all registration cards on this coded item and arrange them in alphabetical order. One would think that this list would not change. However, we keep finding inspections that we didn't realize were performed. So we keep updating the report.

Other reports that are routinely run include a listing of machines that are in storage, a listing of facilities that have been terminated, and a listing of facilities that have fluoroscopes. All the reports that I have just described can be run by simply sorting the registration cards.

We also prepare a report which lists all the facilities that we have inspected since July 1, 1967 sorted in alphabetical order. To do this, we collate all the registration cards with all the facility cards from our inspections. These cards are collated by comparing registration numbers. Thus, each registration card that has a facility card has been inspected since July 1, 1967. These cards that match are arranged in alphabetical order and listed.

The cards that don't match are the facilities that have not been inspected. We list these facilities in alphabetical order by county. In other words, we have a separate sheet of paper for each county which contains the facilities in that county that have never been inspected.

Now one might ask, "What can you do with all these listings?" Actually, we compile the listings into a book which the inspector can take in the field with him. They do make extensive use of these particular reports. Incidentally, it only takes approximately two or three hours to run all the reports. You will recall that Richard Fry mentioned their priority system earlier. Since we are not quite as far along as the Kentucky Program, our present priority system is (1) to inspect all the facilities that have never been inspected emphasizing the inspection of fluoroscopes first, (2) to inspect all facilities that were inspected before July 1, 1967, (3) to inspect the facilities inspected after July 1, 1967 and originally found in noncompliance and then those that indicated compliance by communication.

Armed with the inspection priorities, the inspector may very effectively plan his work. First, he would probably open the book to the never inspected list. Assuming he knows which county he plans to work, he can open to all facilities never inspected in that county. Using the fluoroscopy list, he can cross check to see how many of these particular facilities have fluoroscopes. He would probably make sure that he inspects these facilities on this trip.

After his plans are completed and he has arrived at his first facility, he may find that he is unable to conduct an inspection immediately. We do not make announced inspections. However, at that point in time he may make an appointment for later in the afternoon or the next day. If he has trouble getting into the facilities he had planned to see, he can open the book to the gross alphabetical listing by county and pick out the closest facilities. He can determine the compliance status based on the previous inspections for the facilities. He can also cross check on the facilities in the area that have stored machines.

The point I am trying to make is that our inspectors have in the field the bulk of our records in a very manageable form and can use them more efficiently to conform to our priority system and to efficiently plan their work.

One might ask, "What other uses one could make of this system?" You have seen the use the inspector makes of these reports in the field. Also, we can use this system to run special reports such as filling out the annual PHS report. As you know, the information requested in this report has been changing somewhat each year. Thus, trying to keep records based on the information requested from last year's report doesn't always work. We feel we have the flexibility within this system to provide very quickly any information that we have in our files.

We have been able to prepare special reports for professional groups. For example, the North Carolina chiropractors were interested in knowing how they stand, as a group, regarding to the use of x ray. They requested a special report on how many chiropractors we have inspected, what the status of these machines were, meaning how many were in noncompliance and what the most frequent item of noncompliance was. Reports like this can be run quite easily.

We have also had requests from newspapers particularly from the Charlotte area. They were interested to know the status of x-ray equipment in Charlotte. We were able to sort out on Charlotte and give them the number of machines in that city, the number that had been inspected by category, and the compliance status. We are able to group these data in any different ways and thus handle a variety of requests.

What are some things that one could do to more effectively manage their program? I think a very nice example is something that we have recently done. This was brought up today by Hanson Blatz, and has also been mentioned by several other people. We are constantly recommending to dentists that they use the fastest film possible. We said, "Wouldn't it be nice if we had a list of all the dentists in North Carolina that had mechanical timers and are not using fast film."

We took our dental survey cards which have coded whether or not the machine has a mechanical or electronic timer. We sorted all the dental machines that have mechanical timers and took this deck and sorted out the cards on the film classification code. All of those facilities not using fast film were the ones in which we were interested. We took this deck, collated them with our registration deck and came up with the registration cards that identified these particular facilities. We next put them in the accounting machine and listed their addresses on Tab-U-Labels. All that remained to be done was to peel off these labels and stick them on the envelopes. Thus, in a couple of hours we were ready to mail out to this particular group. We mailed a letter encouraging each dentist to use the fastest film possible. We provided a table in the letter with mA and time settings to use for various commercial speed group D films.

Next we were interested in mailing to all the dentists with electronic timers who were not using fast film. We made similar sorts and mailed out a different letter to this group.

This is a simple example of some of the things one can do quickly. I am sure each of you has people sitting around your office saying, "Wouldn't it be nice if we could do this?" In the case of our system, all you have to do is say, "Do it!" Give them the cards and they can run any particular reports they may wish to have.

This is all I wish to say, but I do want to emphasize that the beauty of the system that we are using is flexibility and simplicity. It can be modified in a variety of ways to handle what needs you may have. Thank you.

DR. KINSMAN: Thank you, John.

Any questions for Mr. Shaver?

DR. PARROTT: Parrott, Oregon.

I wondered if you use zip codes in your sorting technique?

MR. SHAVER: No. The only reason the zip code is there is for addressing.

DR. PARROTT: It is very convenient for sorting for counties and particular cities and locations.

MR. SHAVER: We code that separately. We are using IBM city-county combined so we have got that. It may be redundant, but we have a lot of redundance in our system. It is a nice thing we picked up from AEC.

MR. McHARD: McHard, Oklahoma.

John, we are in about the same position that you are on the coding. I wonder if you use a very formalized system of correcting errors that creep into the coding--not the coding system, but the cards themselves--or whether you do it, let's say, as the responsibility of a person that finds this. Just how do you approach this?

MR. SHAVER: We find many errors, such as the wrong county codes, the wrong number of machines, etc. Many updates are also required. We have a box that we keep in the office for corrections. Whoever finds a mistake pulls the proper punch card, the necessary documents that have to be changed and changes them. He writes on the punch card the change to be made and throws it in the box. We accumulate these, and at the end of the month, we take them to data processing and change them.

I just think it is next to impossible to get all the little errors out of the system. We found many errors and we keep catching them. We had 15 people we found just last month coded in the wrong county. They were in the City of Henderson and were coded in Henderson County.

MR. McHARD: May I ask one more question quickly? What do you do about duplicate registrations? For example, we had one where we had about 25 or 30 doctors claimed they all owned a piece of one x-ray machine.

MR. SHAVER: We have several of these. I don't think we have one quite as large as that.

To handle this, we only put--you know, in our coding, we have only room for one name. So we put the first person's name on the coding record. Our secretary keeps an independent system, and it is strictly for this. She has the name of every man that is registered. It is cross-referenced as to which registration number he has assigned.

This gets to be a problem out in the field because you say, "Hey, I found one that is not registered." Then you get back in the office, check the file and find that he is registered with another person. That is the only reason we have that file.

DR. PARROTT: We have a perfect solution for that. We charge a $10 fee per machine and nobody wants to own it.

DR. KINSMAN: Any other questions?

Thank you.

Many thanks to all the participants in this particular session on x-ray control in the healing arts. We have been in it some 20 years, and you can see the problems that we still have. I am sure we have got a long way to go in getting more control on the x-ray in the healing arts. I think we should exercise more control.

I don't think the public should clamor for curtailment of or reduction of, the exposure to the general population from the nuclear plants when it is now down to the order of five millirems per person annually and we are exposing the general population gonadally to an annual dose of 55mrem which is more by a factor of about 11 than the exposure from nuclear plants.

DR. MILLER: Thank you, Si. I want to thank both you and Roy Parker for the excellent job you did in moderating the sessions today, and all the speakers on the excellence of their presentations.

I was hoping to see just a few more questions and a little bit more debate, but I am sure that will come tomorrow.

APPROACHES TO THE CONTROL OF ELECTRONIC PRODUCT RADIATION (continued)

NONIONIZING RADIATION SOURCES

Moderator: Gerald S. Parker[1]

MR. PARKER: Good morning. I would like to welcome everybody this morning.

I would like to call on Mays Swicord from the Bureau of Radiological Health to give us a formal paper on the instrumentation that we will all be using for microwave surveys.

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[1] Assistant to the Commissioner, Massachusetts Department of Public Health.

MICROWAVE SURVEY INSTRUMENTATION

Mays L. Swicord[1]

I was asked to speak to you this morning on microwave survey instrumentation. I was also informed that the background of those present would be varied and that it may be inappropriate to begin presenting instrumentation without first discussing some of the problems and difficulties involved in making microwave measurements. So I have tried to divide the problem areas up in a specific manner as shown in Figure 1.

The first problem area, of course--no pun intended--is the operator. In fact, we could list all the problems under a heading, "Training of the Operator." However, this is rather unfair when most of the problems can be eliminated by proper design of the instrument. So I have listed only one problem under this topic and the title of it is Apparent Power Density (near and far field).

The instrument itself is divided into three parts. Under the antenna, I have listed standing waves and polarization.

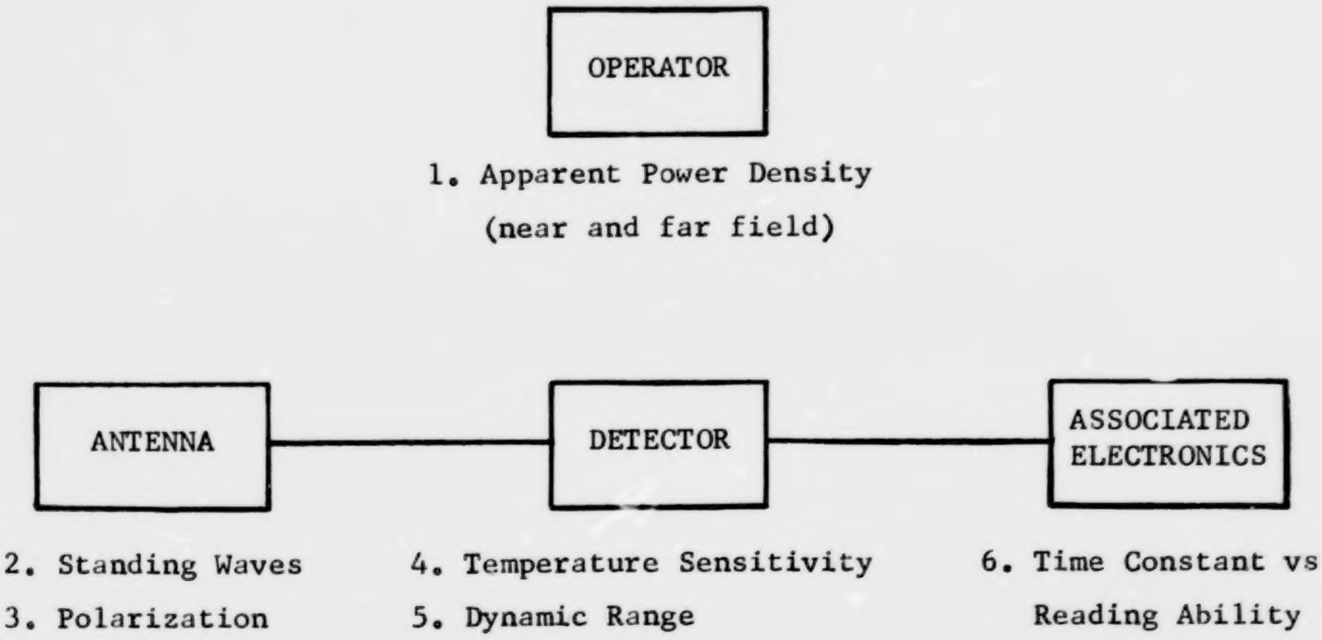

Figure 1

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[1] Staff member, Radiation Measurements and Calibration Branch, Division of Electronic Products, Bureau of Radiological Health, Public Health Service.

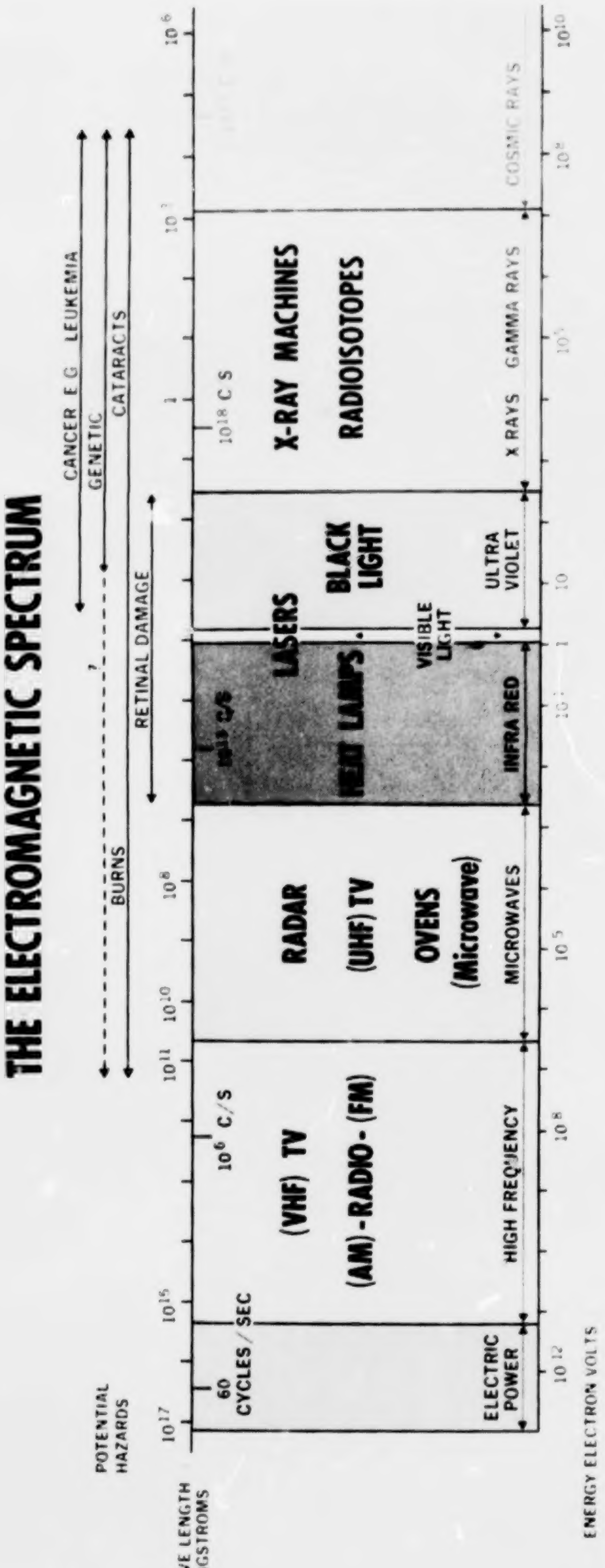

THE ELECTROMAGNETIC SPECTRUM
POTENTIAL HAZARDS
BURNS
?
RETINAL DAMAGE
CANCER E.G. LEUKEMIA
GENETIC
CATARACTS
WAVE LENGTH ANGSTROMS
10¹⁷
10¹⁵
10¹¹
10¹⁰
10⁸
1
10⁻⁶
60 CYCLES/SEC
10⁶ C/S
10¹⁸ C/S
ELECTRIC POWER
(VHF) TV
(AM)-RADIO-(FM)
HIGH FREQUENCY
RADAR
(UHF) TV
OVENS (Microwave)
MICROWAVES
HEAT LAMPS
LASERS
INFRA RED
VISIBLE LIGHT
BLACK LIGHT
ULTRA VIOLET
X-RAY MACHINES
RADIOISOTOPES
X RAYS
GAMMA RAYS
COSMIC RAYS
ENERGY ELECTRON VOLTS
10⁻¹²
10⁻⁸
10⁻⁵
10
10¹⁰

Figure 2

Under the detector, we have temperature sensitivity and dynamic range. We could list various detectors involved which would be either temperature type detectors or diodes. We will go into these later.

Under associated electronics, we have time-constant versus readingability listed.

If you will note, these problems are the problems that would be associated with a radio engineer or electronic engineer rather than those that would be associated with a person working in the x-ray or gamma ray region.

The electromagnetic spectrum is shown in Figure 2. Far over to this side, we have the microwave region which is in and overlapping with the communication region.

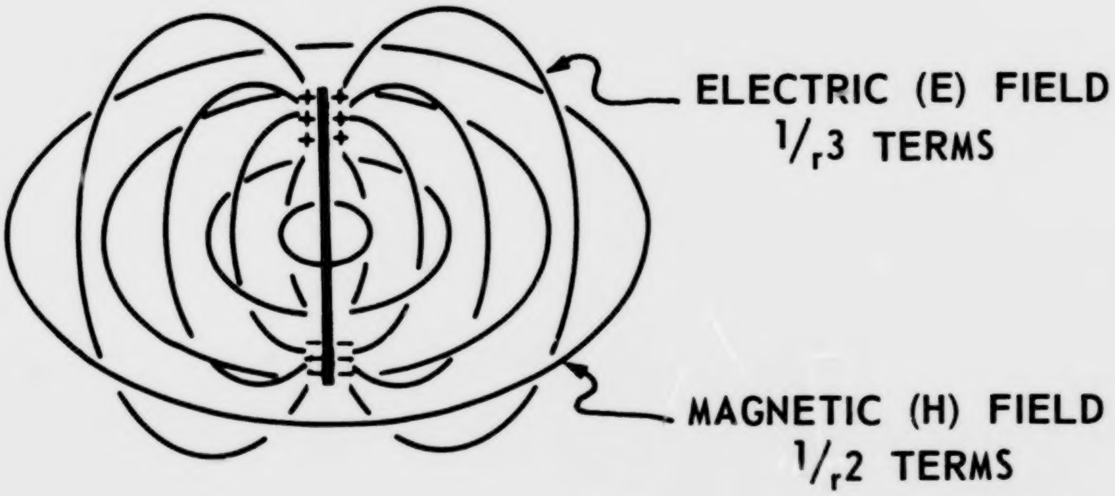
Way over this way we have the x-ray region. And so one would naturally suspect that these problems would be more associated with the communications' engineer rather than with the physicist working in the x-ray region.

The definition of the microwave region is rather arbitrary. One working in the field usually defines this as the region in which waveguide and resonant cavity techniques are useful. These begin to be useful about 1 GhZ. However, most people have extended the terminology of the microwave region to include 300 megahertz to 300 gigahertz.

Since microwaves are electromagnetic in nature they do, however, possess all the general characteristics of visible light and can be reflected, refracted, defracted, polarized, converged or diverged, and absorbed by suitable media.

The mechanism of absorption would be quite different and, therefore, the method of detection would be quite different from, say, the visible region. Whereas in the visible and x-ray and gamma ray region, one would have enough energy for ionization, and you could use ionization as a means of detection, the energies in the microwave regions are somewhere between 10^{-8} and 10^{-3} electron volts and far too small for ionization. So one is not concerned with the detection of a single photon, but rather with the detection of the electric or magnetic field generated by the super-position of many photons.

The creation of the electromagnetic field or generation of EM waves is not a simple concept. But I feel that this is necessary to try to simplify in order that we may understand the near and far field problems. So let's take a simple example--that of electric dipole--and observe the generation or try to visualize the generation of the electromagnetic waves.



ELECTRIC AND MAGNETIC FIELD LINES VERY NEAR TO A DIPOLE

Figure 3

Figure 3 depicts an electric dipole. There should be a break in the middle.

Due to the charge distribution and charge motion along the wire--consider the center line as the wire--we will generate an electric (E) and magnetic (H) field as shown. These fields would be termed the quasi-static or the near fields.

Let me digress for a moment here and ask you to note the lack of symmetry of the situation. The radiation pattern or fields are not spherically symmetric. This means we must be concerned with polarization as well as with the direction of propagation of the incoming wave. We will come back to this point a little later on.

These varying fields are not static fields. We are driving currents in this wire so as to generate electric and magnetic fields. The change in the electric field generates a magnetic field and vice versa.

The illustration would become quite complex if we included the induced fields. The fields both shown and the induced fields can be represented mathematically, however, as shown in Figure 4.

$$E_r = 2A\,Z_o \cos\Theta\left[\frac{1}{2\pi}\left(\frac{\lambda}{r}\right)^2 - \frac{j}{(2\pi)^2}\left(\frac{\lambda}{r}\right)^3\right]$$

$$E_\Theta = A\,Z_o \sin\Theta\left[j\left(\frac{\lambda}{r}\right) + \frac{1}{2\pi}\left(\frac{\lambda}{r}\right)^2 - \left(\frac{j}{2\pi}\right)^2\left(\frac{\lambda}{r}\right)^3\right]$$

$$H_\phi = A \sin\Theta\left[j\left(\frac{\lambda}{r}\right) + \frac{1}{2\pi}\left(\frac{\lambda}{r}\right)^2\right]$$

Where:

$A = I_o\ L\,e^{j\omega\,(t - \frac{r}{c})}$

$Z_o = \frac{1}{\xi_o c}$ = impedance of free space

L = length of dipole

I_o = current in antenna

ω = angular frequency

c = velocity of light

λ = wave length

r = distance from dipole

Θ = angle between direction of dipole and direction of vector r

Figure 4
Total Fields Around a Small Electric Dipole

Ignore everything except what is in the brackets. Note that this is an expression for the E and H fields about a small dipole, a small electric dipole. This is a special case, a simplified case, that we are trying to use as a tool for our understanding of near and far field problems.

Note that in the fields, we have terms, for example, in the middle equation of "one over R," "one over R squared" and "one over R cubed." Note these are not just "one over R" but are proportional to "lambda over R" in all cases.

R is the distance, lambda is the wavelength. As we move in distance away from the source, different ones of these terms will dominate. Very close to the source where "lambda over R" is much less than one, the "lambda over R cubed" term will dominate. We observe again the quasi-static or near-field as was shown in Figure 3.

Now we can detect these fields. This is not the radiated power, but we can certainly detect these fields. We can couple energy from them. We call this radiationless resonant energy transfer.

A parallel example is the coupling of energy from the primary to secondary of a transformer. As we move away from the source, we get into the region where "lambda over R" is about one.

Notice the constant term is "two pi." These will affect the magnitude. When the middle term becomes more dominant, we have reached the intermediate field or the induction field as some people term it.

Then, as we move further away from the source where R becomes large with respect to lambda, we come into the far field or the radiation zone. Note, too, that these fields are mutually perpendicular in this case.

Now, let's consider for a moment the far field case. Let's suppose that R becomes large with respect to lambda, and we can neglect the higher powered terms.

In the next figure, we have the simplification of this problem.

1. $E_{\Theta} = A\, Z_o \sin\Theta\, j \left(\frac{\lambda}{r}\right)$
2. $H_{\Theta} = A \sin\Theta\, j \left(\frac{\lambda}{r}\right)$
3. $P_r = EXH^*$ (Poynting vector)
4. $P_r = \frac{1}{2} \frac{|E|^2}{Z_o} = \frac{1}{2} |H|^2 Z_o$ (Far field, average power density)

Figure 5

The constant was listed in Figure 4. We are only concerned with the "lambda over R" terms.

Note that this is the far field condition or the far field equations. From this, we can calculate the radiated power, the total radiated power, which is given by the Poynting vector in Equation 3 which is simply "E cross H."

In the far field, we have the simplification of the total radiated power density. We do not have to measure both E and H. Since they are related in the far field by an equation, they have a constant relationship. In fact, the ratio of E to H is called the impedance of free space which is numerically equal to 377 ohms. This is not true, however, as we go back into the near field. E over H is not equal to the same constant. The ratio of E over H varies as we move into the near field. Therefore, we cannot get into the near field and say we are measuring the radiated power.

However, in the far field, since these two are related by a constant, we can measure just one of them--E or H. E can be measured most easily. You can use a dipole antenna. Or there are a lot of antennas that we can use.

H is also rather easily detected. The method of detection depends on the frequency. When you get up very high in frequency loop antennas, things of this sort become rather small and complicated and very difficult. It can be done. And, in fact, "E cross H" can be measured by using the Hall effect. This may be a lab type experiment that one does not perform in the field. It may be very cumbersome and very impractical to do in the field. So one usually measures E or H. Since E is probably the easiest to measure, then one would want to measure E.

This is most fortunate because E is probably the biologically hazardous quantity. Our bodies are most likely E field detectors. They are not going to absorb a single photon at these frequencies. They are going to absorb energy from the E or H field. It is probably the E field from which energy is absorbed.

The absorption of energy from the E field results in absorption of energy from the H field and vice versa. It is the mechanism of absorption that we are considering.

We can build a probe which is an E field detector and calibrate it in milliwatts per centimeter squared, which is the unit of power density. This is due to the fact that Z_0, the impedance of free space, is a constant once we get into the far field.

What happens once we move back into the near field? Our probe is going to detect the near electric field. We are going to couple energy by radiationless resonant energy transfer from the near field.

Therefore, we are reading incorrectly the radiated power density. We are not reading the total radiated power. We may be reading something greater than the total radiated power because we are coupling energy directly from the source.

We can consider this all bad; however, it may be most fortunate because, as I mentioned before, the body is probably an E field detector anyway. So the body is going to couple energy from the near field also.

Even though our instrument is giving us a reading in milliwatts per centimeter squared, maybe we are using the wrong units for measurement of hazard. A lot of people think that the unit should be changed from milliwatts per centimeter squared to something that is related to the E field squared so that we don't indicate we are reading radiated power density for all hazard purposes.

I prefer the term that was listed in Figure 1, apparent power density, because we do have an apparent power flow into the body. You will hear a lot about this in the future if you haven't already--the near and far field problem, whether one is measuring indirectly or directly the radiated power density. One is usually not measuring radiated power density in oven surveys. Rather, one is measuring apparent power density because in most cases, particularly when we are measuring around microwave ovens, energy is coupled directly from the source.

I have given you the impression, I think, that the near and far field separation is dependent upon the distance that we are away from the source. This is not the only factor. Keep in mind that I am giving simplified, hopefully simplified measures here as illustrations.

One other complication of the problem is the size of the antenna. The size of the antenna is going to affect the space around it. In other words, if we have a larger antenna, its effect will apparently extend further into space and create the condition where we have the near field extending further into space than we would from an electrically small antenna. Therefore, an arbitrary definition--and this is a very arbitrary definition--of the separation of the near and far field or zone is "$2D^2$ over lambda" where D is the distance or the size of the antenna and the radius of the antenna. Lambda, is again the wavelength.

"$2D^2$ over lambda" is really a measure of how plain the waves are or how parallel the waves are. It says that at that particular point, the phaseover from all points of the antenna will vary by an amount which is from one end of the antenna to the other 22.5 degrees or less.

Well, that seems like a very nice number, and it is arbitrary. However, at "$2D^2$ over lambda" you will still be in the near zone. You will find that if you extrapolate back from this point, from an antenna, and read on further back that you will not fall off directly as "one over R squared" in power.

Let's move on from the problem of the energy field and far field to a problem which usually is associated and termed the near field and far field problem. I would like to separate these two problems, however, and call this not the problem of the field or the measurement of the field, but a problem of measurement near the source which is usually in the near field.

If we have a large antenna for a receiver located near a source such as a crack in an oven door or even a radar antenna, if you like, if you can get close enough to one, provided you turn it down low enough in power, you are going to have reflections from the antenna back towards the source.

Now, these reflections will depend upon the impedance characteristics of the antenna or detector that you have placed here. If this particular antenna or probe, the received probe, is matched to the space around it, we are going to absorb the total energy that is radiated there. If it is not, if the impedance is different from that of the space--in other words, if you had this in free space and the antenna impedance was 377 ohms, the wave will see no boundary. And it will not be reflected. It will be absorbed or transmitted on through the material.

Usually, though, when we put a large metallic object there, this impedance is very small compared to free space and, therefore, we set up currents in this metal. And we have reflections back towards the source. These reflections, which we can call scattering back towards the source, are going to affect the field in between the two antennas. We can look at this from two viewpoints:

We can say that this will establish a standing wave in between the two areas; or

We can say that the scattered wave goes back to the source and affects the wave that is transmitted from the source.

We have a contract with IITRI, Illinois Institute of Technology Research Institute, to perform some measurements and calculations on the effect of antenna size in and close to a source. They are using a slot antenna as a source and a dipole antenna as a receiver.

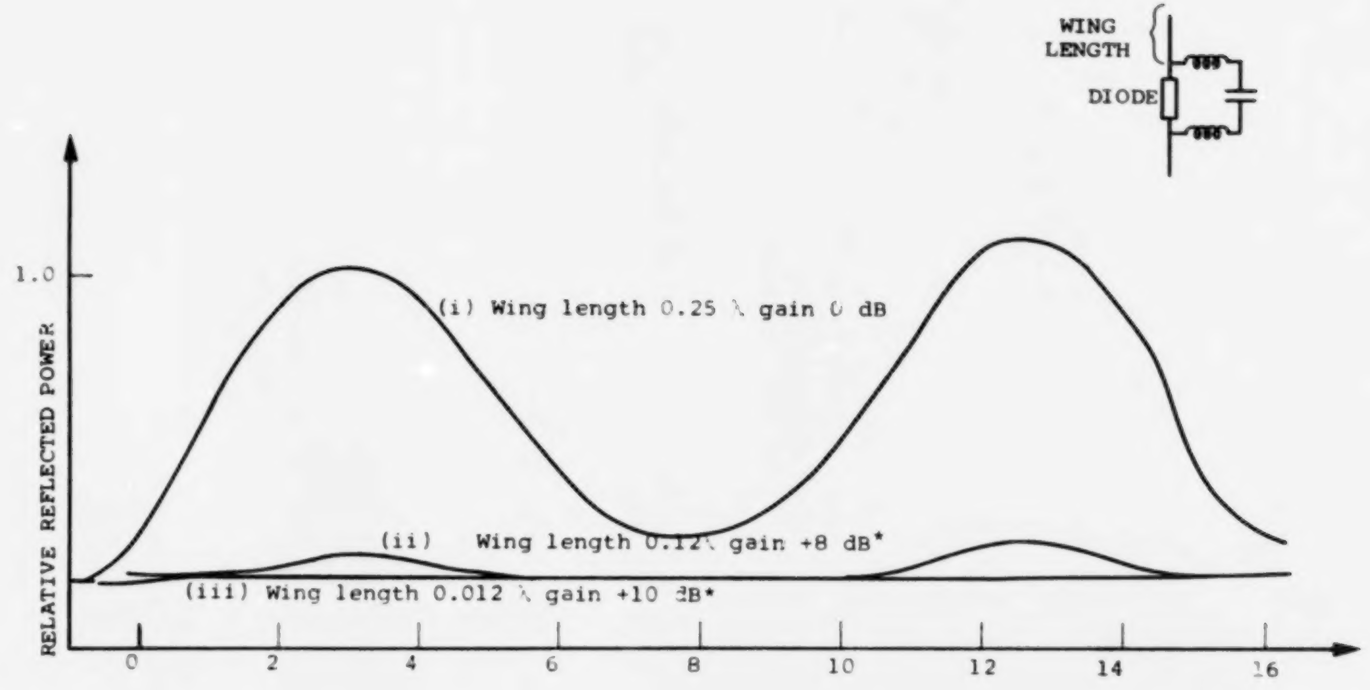
In Figure 6 the probe antenna has been moved along the length of the slot. This is not away from the slot, but along the length of the slot, and we can note the reflected power back into the source. This is reflected power, not received power by the probe as a function of antenna length.

Now, for a wing length, as they call it--note the wing length indicated here-a quarter wave which is the classical link for communication reception purposes, where you are interested in getting a large signal, you have tremendous reflections back into the source. As you decrease the length down to .012 wavelengths, note that the reflections smooth out.

Note the simplicity of this antenna. We have here a combination of antenna and detector. The detector is a diode. The antenna is simply the leads of the diode that have been clipped. This is a very, very small antenna.

In Figure 7 we can see the effect of moving the small probe antenna away from the slot source.

Note that the dotted line is for an antenna with wing lengths of 0.16 lambda. The hard line is for a quarter wave antenna.



*Gain increase refers to reflectometer receiver.

Figure 6. Relative reflected power when probes with wing lengths given are passed along slot at 2cm above groundplane.

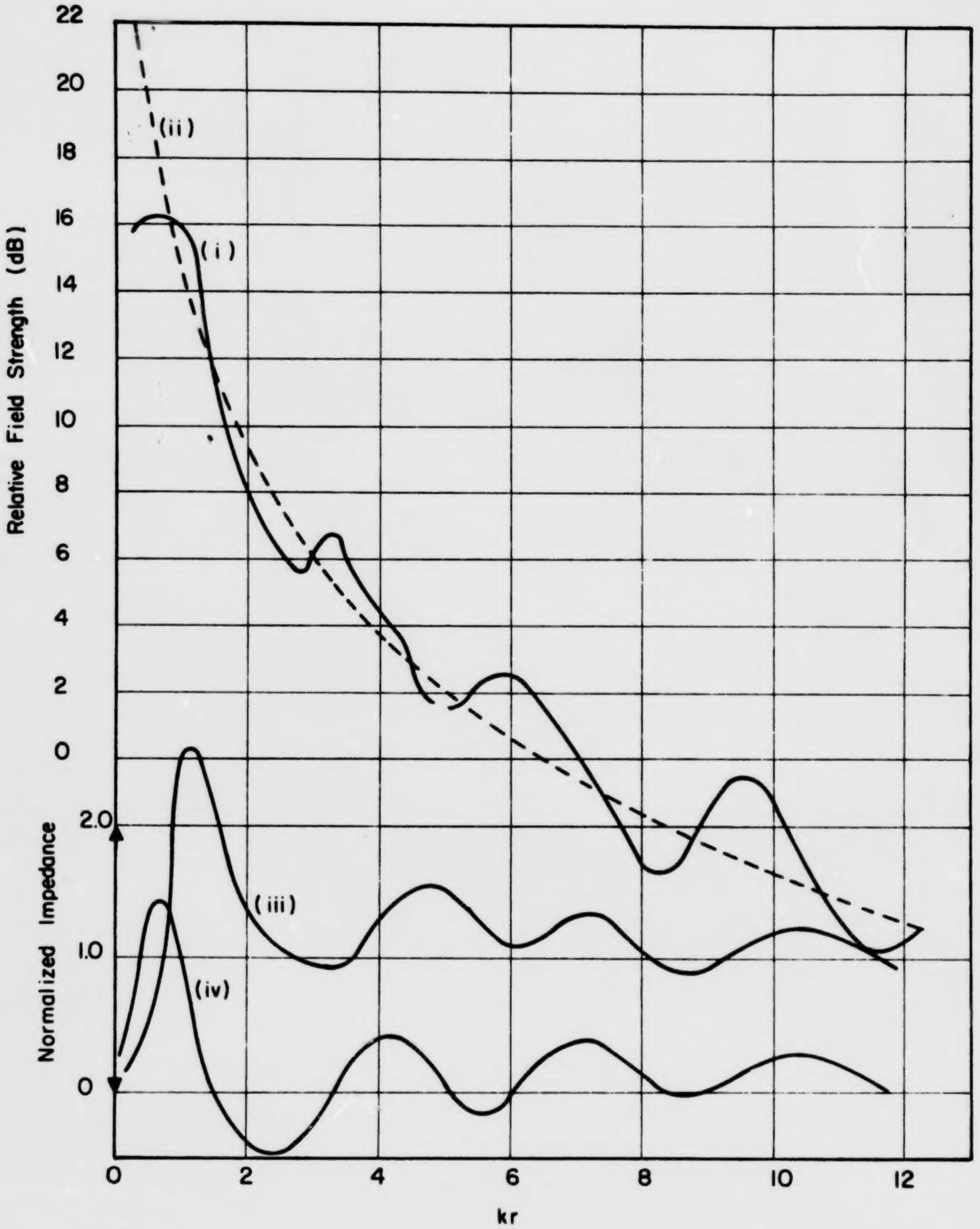


Figure 7
Illustrating effect of dipole impedance variation on field strength measurements. Field strength measurements approaching a 6.1 cm slot in a large groundplane. (i) basic probe dipole with 0.25 λ wings. (ii) basic probe dipole with 0.016 λ wings. Typical impedance variation of an 0.25 λ wing length dipole approaching large groundplane. (iii) resistance. (iv) reactance f = 2450 MHz.

Do note that the scale is in dB. These variations are about 1 dB at this particular point which is 25 percent in power.

Well, this problem can be eliminated, of course, by proper design for our probe. If you want to measure within the near field without reflections, you want a small antenna.

I would like at this time to talk about one other effect, that of polarization of the antenna. We have already noted previously from the Poynting vector that the direction of propagation is perpendicular to E and H. This means that in the far field, your E field and H field are going to be mutually perpendicular and both are perpendicular to the direction of propagation. Therefore, when we are receiving the signal with an antenna, we are going to have to worry, not only about the direction of propagation, do we have our antenna pointing towards the source, but we are going to have to worry about the orientation of the dipole.

If the dipole is pointed in this direction and the incoming wave is polarized, the E field is wiggling back and forth along this direction, we are going to receive absolutely nothing. So we have got to rotate our antenna in order to receive the incoming signal. The polarization problem can be eliminated by proper design.

We can develop an antenna which will receive and be insensitive to polarization by using crossed dipoles or even three orthoginal dipoles if we are worried about reception from all directions in space.

I would like to spend a few moments talking about detectors. This is not a great problem, but one should know what type of detector is used with a particular device.

I mentioned before that we can separate detectors into two types--principally those that respond to a temperature change due to the absorbed power, absorbed energy, and those that produce a current or a voltage due to the presence of the electromagnetic field.

In the first category, we can again subdivide into two sections. And we can talk about the bolometers which change resistance, have a resistance change with temperature. These are used in a bridge circuit. When power is received into the bridge circuit, heat is dissipated in the resistors. This causes resistance change which causes imbalance in the bridge which in turn is registered on a meter.

The second temperature type is a thermocouple. We can simply cause reception of the signal to heat up a particular metal and detect this with a thermocouple and get a direct readout.

The next, the third category, is the diode. We can use the nonlinear characteristics of the diode to rectify our signal and receive information from the incoming wave. You can use the diode in two different ways.

We have contracts with both IITRI, as I mentioned, and with the National Bureau of Standards. Both of these groups are developing probes using diode detectors.

The diode has a region of linear detection and a region of "square low" detection. The former occurs for signals of approximately 5 mW or greater and the latter for inputs of approximately 0.1 mW or smaller. These numbers should change or vary according to the type of diode being used. The square low region provides direct power measurements. If operated in the square low region a limited range and power measurement capability is provided.

You can see that in the linear region, you would be limited on the upper end by signal strength or else you would go into the square low region and your response would become nonlinear. This can be compensated for by other circuitry. There are limitations in the other case where you are operating in the linear region. There, one has the problem of squaring the signal once it has been detected so that you can read out in power.

So there are complications with both methods, but both methods can be used. So much for detectors. Let's not dwell too long on that. It is a design problem, but you should be aware of which type instrument you have, particularly the fact that they both have limitations.

The thermocouple has limitations in that it can be easily burned out if you exceed the rated power density. The same is true for the bolometer. The bolometer is more sensitive to ambient temperature changes. Of course, the thermocouple is, too.

These both can be designed out, but the problems involved are great in that it requires a lot of circuitry to get rid of the effect of ambient temperature. You can get rid of the effect of ambient temperatures with thermocouples by making a hot and cold junction in close proximity.

Let's move on now for a moment and take up the problem that we had listed under instrumentation.

We want to talk about instrumentation and response time.

In Figure 8, we have depicted the response of the Narda 8100, which is an instrument we will mention in a moment, to a step input signal.

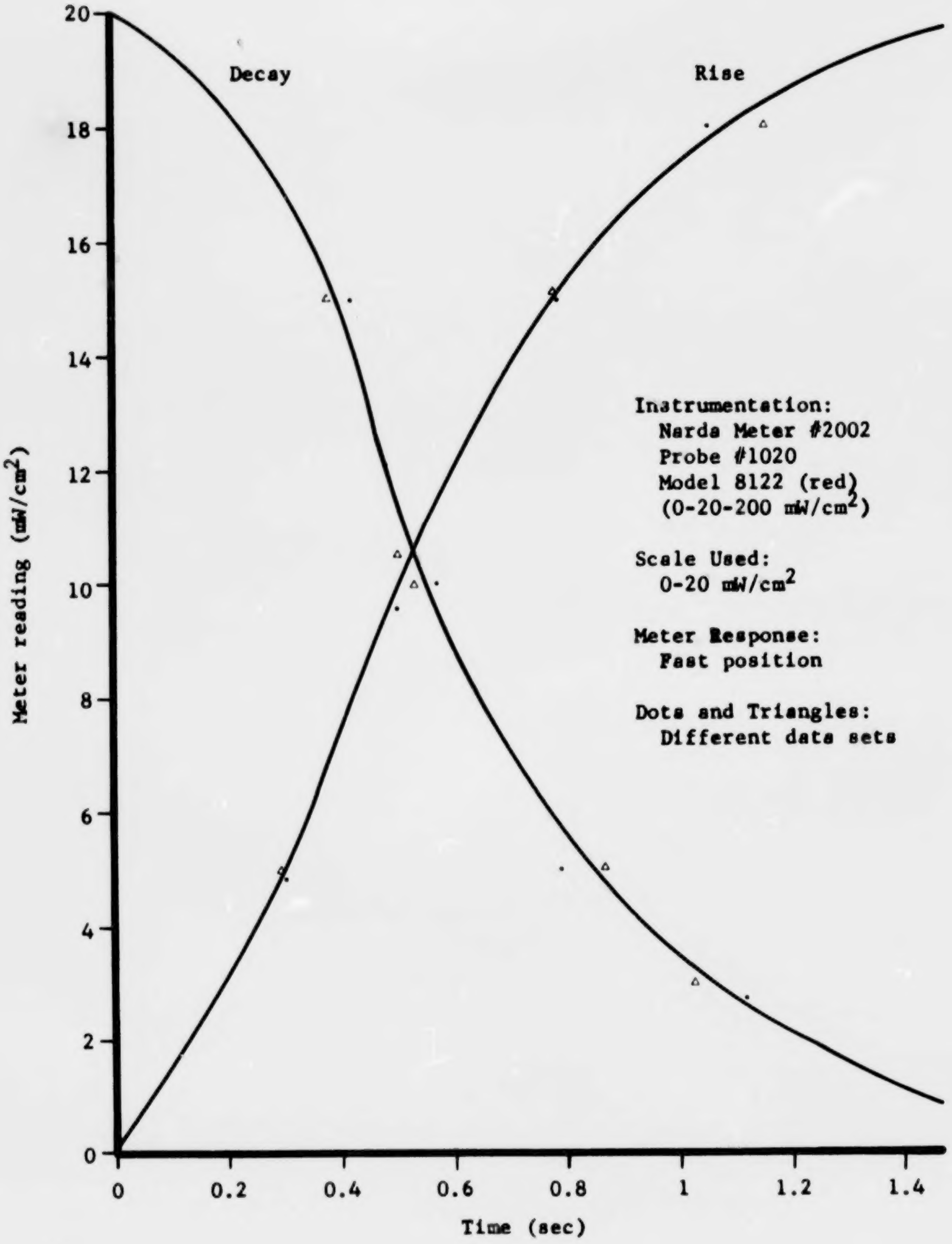


Figure 8
Fast response of Narda 8100 to stepped RF input,
Model 8110-8122 combination.

This is the fast response. The Narda 8100 has two optional response times in the instrument. We apply to the instrument a certain power density (in this case 20 milliwatts per centimeter squared maximum), and the meter sometime later reaches that maximum. This graph illustrates the response.

The presence of a meter movement is going to be a limiting factor in the response of the instrument. A meter movement will result in about a 1-second response time. One can obtain meters which are a little faster and one can also digitalize to obtain an even faster response. We are not talking about the rise time, but the response time, 0 to 90 percent time. For the instrument shown in this slide, this is on the order of one second.

In Figure 9, you can see that for the same instrument under another position which Narda calls the slow response position, we have extended the response time, 0 to 90 percent response, to about 6 seconds. What effect does this have on measured power?

In Figure 10, note the leakage from a particular oven.

If you can see the line wiggling along here, the upper line indicates data recorded using the fast response. Note the wide variations.

If we use the slow response, we damp out these variations. In effect, we are getting an average reading.

So the problem is what does one want to measure? Do you want to see these peaks? If so, you have got to have a fast response instrument. Do you want to average? If so, you want to make the response time a little bit longer.

However, you cannot carry this to an extreme. A 15-or 20-second response time instrument may endanger the operator. The operator may be overly exposed while the instrument is building up to its peak value. So there is danger in very long response times and there are problems in very short response times depending on what you are trying to measure.

If it turns out that the biologically hazardous quantity is the peak power, then, one has to go back and redesign the instrument so it reads peak power.

Figure 11 shows the Narda 8100, the instrument designed specifically for oven surveys. It has three probes. The various probes give you a range from the lower scale of reading, from 0 to .2 milliwatts per centimeter squared using the blue probe to a maximum of 0 to 200 milliwatts per centimeter squared using the red probe.

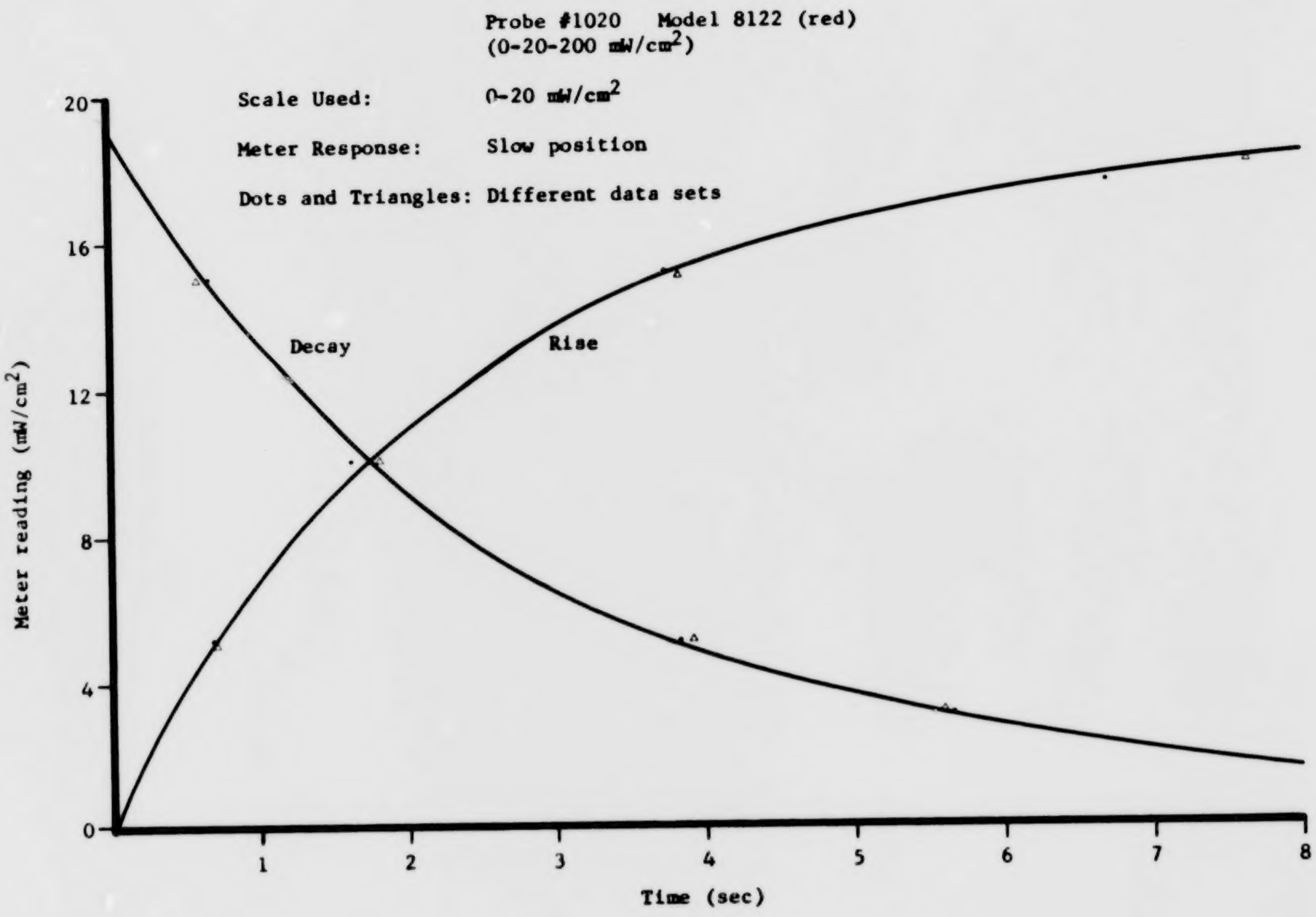


Figure 9
Slow response of Narda 8100 to stepped RF input, Model 8110-8122 combination.

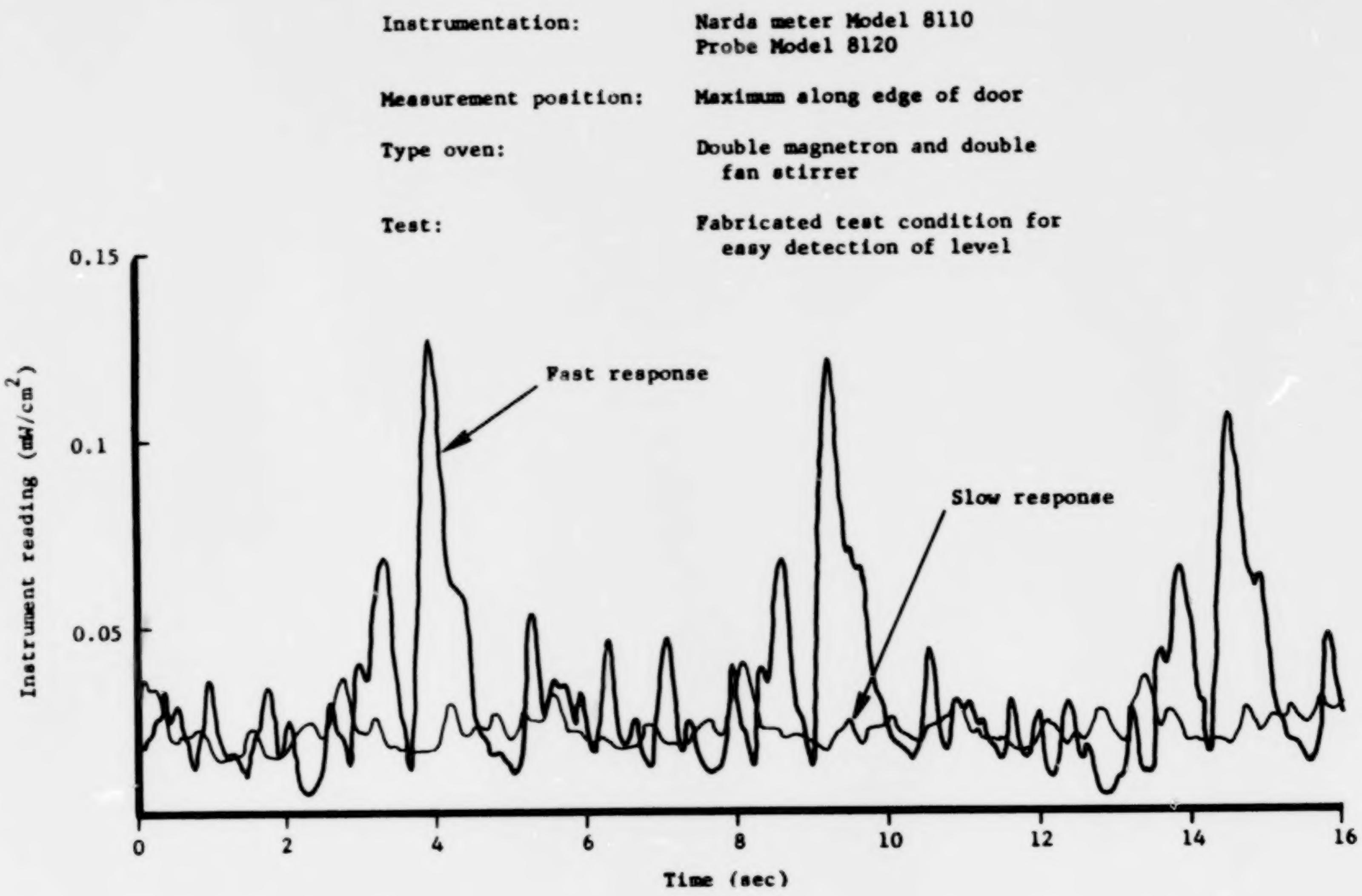


Figure 10
Instrument reading as a function of time (fast and slow response): double fan stirrer.

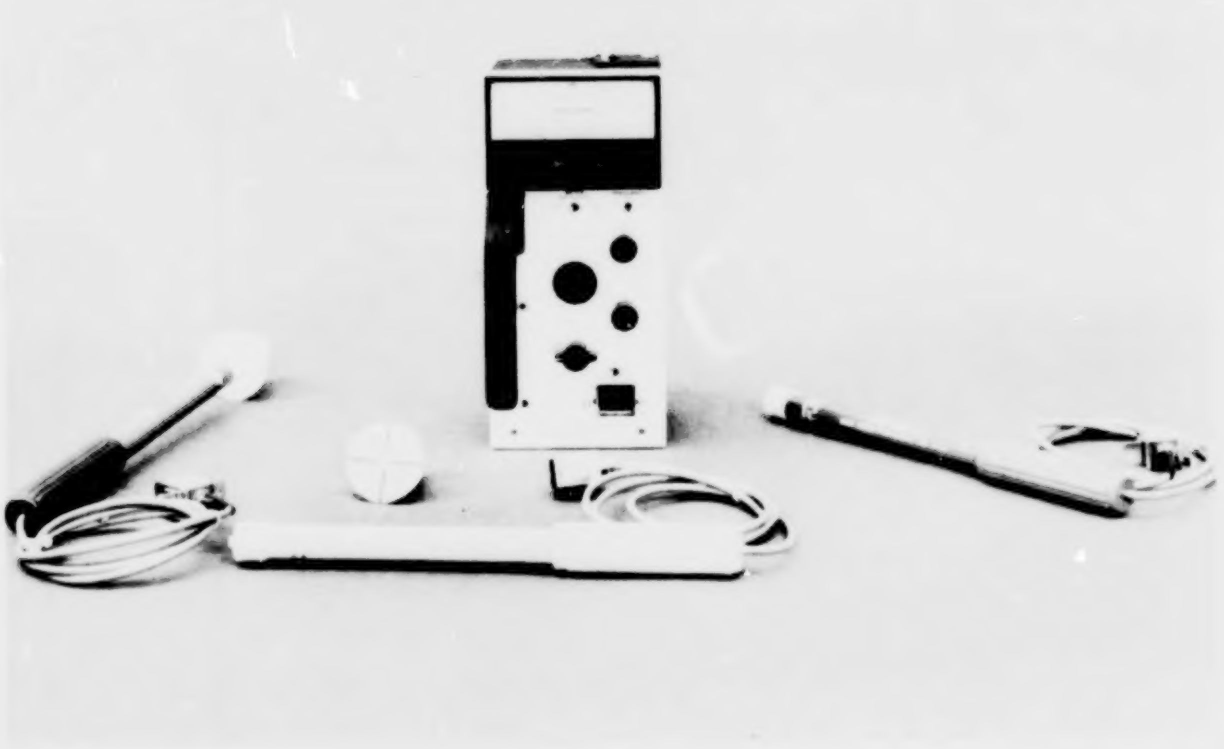


Figure 11

I recommend if you are buying such an instrument you not purchase the blue probe. They are easily burned out. For most cases, you don't need to measure such low power densities.

This instrument has a very small antenna. Note the tip of the probe. At 2,450, that is the extent of the antenna. It is very small. So that we don't have the problem of reflections from the source. At 915, they need more sensitivity so you have to extend the probe length by putting this extension on the end like this. This spacer is for 2,450.

Note it does not have the extra antenna portion sticking in it. That merely is a spacer to indicate a 5 centimeter distance from the oven, which is the designed measurement point away for survey purposes.

MR. CHRISTIE: How much?

MR. SWICORD: If you are looking at the meter and one probe, it is about $800. Each probe thereafter is a little more than $100. So you are running better than $1,000 for the entire instrument.

It is a very adequate instrument. It is expensive. Narda themselves are trying to develop a cutdown model of this at the present time which should range from $300 to $400, still rather expensive.

There are other people that are designing probes at this time in this particular area, trying to meet the need of an inexpensive meter. Sage Laboratories is one of them.

Figure 12 shows the Narda Hazard Hunter.

Due to the fact this is a large device, it has problems with reflections. Paul Crapuchettes, Litton Industries, made some measurements using the Narda 8100 at a fixed position and the Narda Hazard Hunter moving it towards an oven door. The Narda 8100 reading should remain constant. The Hazard Hunter should increase its reading because it is being moved towards the oven door. What happens is that the Narda Hazard Hunter not only reads incorrectly, gives wild variations, but it causes the 8100 to read incorrectly. So then the Hazard Hunter causes scattering back towards the source.

The Hazard Hunter reads from 0 to 20 milliwatts per centimeter squared and has a calibration for frequencies ranging from about 450 megacycles to 12.4 Gz. So it is broad range device capable of use in the radar range.

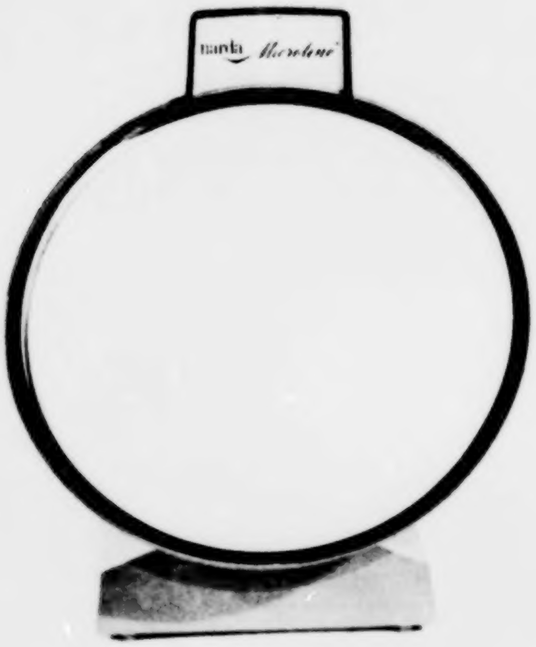


Figure 12

Figure 13

Figure 13 shows another instrument which is comparable to the Hazard Hunter, the Ramcor Densiometer. However, it reads not in milliwatts per centimeter squared, but reads in dB related to 10 milliwatts per centimeter squared. It reads from minus 10 dB to plus 3 dB. If you have your logarithm tables memorized, you have no trouble reading this instrument.

Ramcor has antenna horns to cover the frequency range from 200 MHz to 12.4 Gz. You have to change the antenna horn as you move in frequency. Again, you have a large antenna. This is not the type of instrument one should use when you are making an oven survey.

Figure 14 illustrates a totally different type of instrument, the Microlite made by International Crystal. They were specifically planning an instrument to be used for measuring leakage from their oven. This uses a gas tube made by Amperex to detect microwaves. It is a pre-ignited tube. The instrument has an orange glow when plugged in--when microwaves are detected, a blue glow is noted. The higher the glow up the tube, the greater is the microwave field.

This is not an exact instrument. If you see a blue glow which is sometimes difficult--it depends on the response of the eye--then you know you have microwaves. If you don't see a blue glow, then you are not sure of anything. You can't precisely determine leakage from the oven.

MR. CHRISTIE: Is it frequency sensitive?

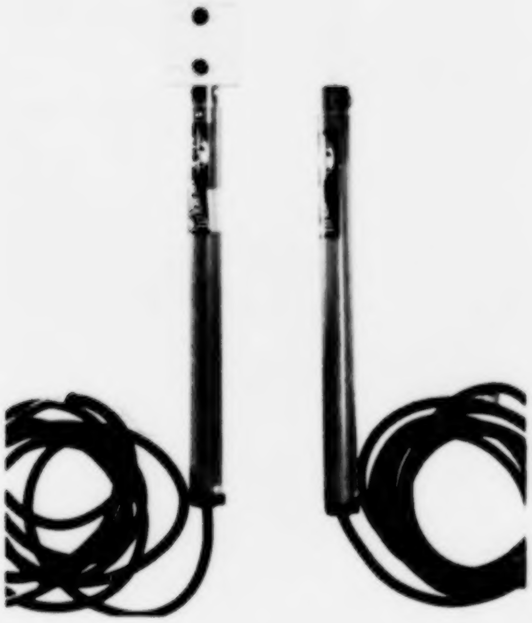


Figure 14

MR. SWICORD: This was designed for 2,450. As far as its sensitivity, I do not know about that. Their design specification was for 2,450.

If you note, there is a wire sticking up in here. I am sure that is not a quarter wavelength. I don't know what it is. But I haven't had the opportunity to investigate it myself as far as its frequency sensitivity.

One can build his own instrument. They are not limited to buying one off the shelf. You can buy off-the-shelf instruments which you can use for this purpose. For example, one can use a power meter. The one pictured in Figure 15 is from Hewlett-Packard.

This particular bolometer happens to be very temperature sensitive. One can make measurements with a power meter and suitable antennas--notice there are several types of antenna laid out here. Again, all of these antennas would be polarization sensitive so that one must know the polarization or one must carefully measure to determine what the polarization is from a particular oven.

This is difficult in a case where you have got an oven with a crack going around the corner of the oven door. You could have multiple sources at that point. Therefore, you could have some elliptical polarization. You may need to get both components to know what the total hazard is. It is best to have in this case a device with cross dipoles which would be polarization insensitive.

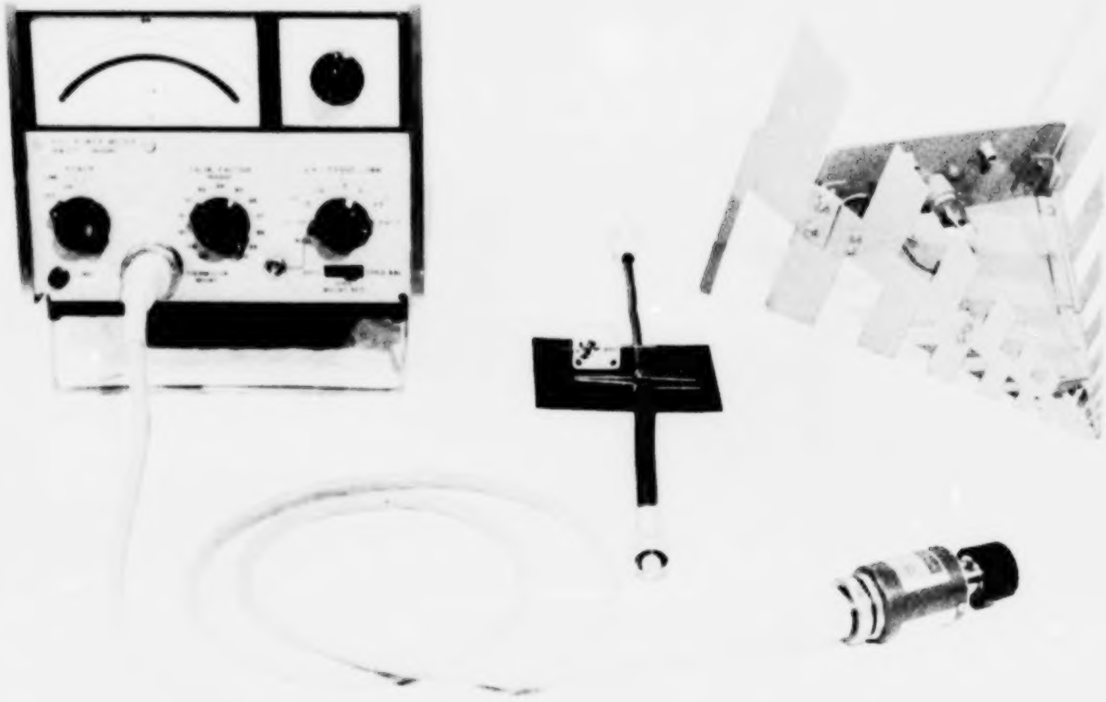


Figure 15

MR. PARKER: There is time for a couple of questions.

MR. HARRIS: How about the calibration of these devices? Who would provide the service if you made your own?

MR. SWICORD: If you make your own, you should be capable of servicing it. We are in the process of trying to establish a calibration facility. We have to do this first for ourselves. If you remember, our division director the other day mentioned the fact that we are going to be supplying instruments to the States. We are going to be calibrating those instruments at our facility. So we will naturally have that facility established for the calibration of those instruments.

Whether or not we will have the time or funds to do anyone else's particular probe, I don't know what the arrangements are on that. Maybe Dr. Elder is around and would like to speak to that.

MR. PARKER: Dr. Elder, do you want to say a few words on that?

DR. ELDER: You know, we run into this problem on calibration of instruments regardless of the capability. We can calibrate PHS instruments and I think this is what Mays is referring to. Those we loan will belong to the Federal Government so we can calibrate them.

I think all of you know the problems we encounter whenever we receive a request for calibration of nongovernment-owned instruments and competing with private industry, so I think we have been handling those on a case-by-case basis whenever there are real problems.

Normally, this facility will be available for PHS instruments at present.

MR. PARKER: Thank you.

The next paper will be by Jerry Karches, the Deputy Director of the Northeastern Radiological Health Laboratory, on an overview of diathermy sources.

AN OVERVIEW OF DIATHERMY SOURCES

Gerald J. Karches[1]

Good morning, friends and fellow participants of the Conference. The subject that I am to talk on today is an overview of diathermy sources. It is another one of the radiation pollutants that was referred to earlier in the week that I think we are going to be faced with doing something about in the coming year.

You might ask: What the heck is diathermy, anyway? This is the question that we asked ourselves about six months ago.

How many of you, for instance, do know what diathermy is, have a rough idea of the subject matter? There are about a third of you. That is better than we were when we started. We were looking at each other for help, and we wound up going to physical therapists textbooks and other sources to try to locate just what the subject was all about.

Incidentally, I also checked Webster as many people have this past week. He defined diathermy as "the therapeutic heating of tissues beneath the skin by means of high frequency electrical oscillations."

Now, does that clarify it?

Since that time, we found that diathermy is a pretty broad field. It covers 2,450 megahertz, the same as the microwave ovens that you will be faced with the next few months which is, of course, the microwave region. It also operates at 27.12 and 13.56 megahertz which is in the shortwave region. It also includes ultrasound, although it is up for discussion by some physical therapists. Ultrasound isn't a diathermy device, but we have interpreted it as part of diathermy. They are used somewhat interchangeably. The units interact differently as you probably are aware, but they all have the same characteristic in that they stimulate blood flow. And this is the main thing they are striving for--to stimulate deep heating and increasing the blood flow.

Some claim much more than just blood flow. In fact, it can probably cure almost anything if you talk to the right people. There was a study that we read about on a pulsed shortwave unit which apparently cured practically all the returning Vietnam veterans after they tried everything else and did not seem to respond to any other treatment. They used pulsed diathermy and, presto, they were out walking the streets again.

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[1] Assistant Director, Northeastern Radiological Health Laboratory, Public Health Service.

When we looked into this--Dr. Cliff Nelson contacted the hospital there that was using it--we found that they have this unit filed away back in a closet somewhere gathering dust. The people that made these claims have left, and no similar benefits from the pulsed unit were observed.

Another question I think you might ask is: Why this sudden interest in diathermy? Don't we have enough problems with the TVs and the microwave ovens and what have you? We thought so, but back in October, Dr. James McTaggart came to a conference in Richmond and asked the question, "What do we know about diathermy?" And it started this chain of events to get us to find out a little more about it.

It turns out he had been contacted by Aaron Bond in New Mexico. Mr. Bond knew of a case in Albuquerque where apparently cataracts developed from the use of microwave diathermy. I would like to give you a little rundown on this particular case which got us quite involved in this area.

There is a 38-year old radiological health officer in New Mexico who has spent years working in the radiological field at Idaho Falls and at a small reactor in Piqua, Ohio. He has been in Albuquerque for about the past three or four years. The total accumulated dose that this individual has received since 1955 is 16.5 rads, most of which were obtained at Idaho Falls. At that time, he had annual eye examinations by slit lamp, and he wore a film badge conscientiously and, of course, was aware of the fields that he was in by using survey instrumentation.

This particular individual was in a bus accident in Albuquerque. He then went to a neurosurgeon who examined his eyes in the course of the examination and told him to just go home and take it easy, he would be all right in a day or two.

It turned out, if anything, he got worse. Then he went to an osteopath who gave him the normal laying on of hands treatment. In addition to that, he gave him, in the course of the next six months--this was from June to December 1968--a total of 12 microwave diathermy treatments. These treatments were for 15 minutes each time.

We made a trip to Albuquerque to make measurements of power density levels. In addition to that, we made measurements in our own laboratory on a similar unit. We also brought the individual to our laboratory and made measurements on the area that we were most concerned with--the eyes. I would like to give you some idea now of what type of treatment this was.

I think you can get some appreciation for what our problems are trying to make measurements when you have all this paraphernalia around the source and introducing a detector in the field. It automatically creates perturbations in the field. Consequently, we are not sure what the eye received. We do know that at the surface of the right eye, he received 33 milliwatts/cm^2. On the left eye, he received about a factor of 10 less.

Arrangements were made for this individual in December 1969 to visit our laboratory and have his eyes examined by two ophthalmologists in Boston, Drs. Cogan and Donaldson. They are noted experts in the field and have taken quite a few lenses from patients--something like two or three thousand per year. We thought it would be wise for someone that has worked in this field quite a bit--in other words, more knowledgeable than we are--to examine the eyes and determine whether this was a possibility of radiation cataracts.

It turns out that radiation cataracts are very characteristic. They are posterior subcapsular cataracts, the same as you would receive from ionizing radiation. However, we think because of the well-documented history that he had by working in the radiological field that we have more or less ruled out ionizing radiation as a cause of these cataracts. Remember he was exposed to 16.5 rads and had annual eye examinations while at Idaho Falls and at the time of the accident, there was no hint whatsoever of cataracts according to a neurosurgeon's report.

When he was examined in Boston he had double vision in the right eye and was practically losing his eyesight in it. The left eye was not too far behind, incidentally. This is a puzzling thing because of the very low power density level--2 to 3 mW/cm^2. This is based, of course, on measurements at the surface of the eye with the inherent limitations on what the eye itself received.

Just to give you some feel for this, Dr. Carpenter who is at our laboratory has been working with rabbits and producing cataracts, this same type of cataract, with microwave radiation for about the past 12 to 14 years. He and Drs. Cogan and Donaldson agree that this type of cataract is very similar to the one that the patient has in New Mexico.

But the readings he is getting with the rabbits vary quite a bit depending on the size of the rabbit. We can get large differences just from a 1.8 to a 2.8 kilogram rabbit. If the rabbit actually moves his ear somewhat during the exposure, we get quite a bit of perturbation in the field. The readings change tremendously, a factor of 2 or 3 difference.

Incidentally, rabbit ears have been used for many years for radio frequency measurements.

We also found that by just shaving some of the hair from the face of the rabbit, we get differences in the field. So how we are ever going to extrapolate from this rabbit data to an individual is beyond me at this particular time.

We think we are going to award a contract to a company in Boston to develop a dosimeter that will enable us to make measurements in a phantom that will be very similar to a rabbit or a human eye. But we don't have that yet. Consequently, the numbers I quoted you must be taken with a grain of salt because we are not sure that this is what the eye actually received.

The other thing that I should mention is we think there may well be other cases very similar to this because diathermy is used quite a bit as you will see later on. This is a very common technique. The levels that individuals are exposed to in many cases are higher than this. So we think that the reason we discovered this case, or it was brought to our attention, is the fact that this individual was a radiation worker and associated radiation with cataracts.

His brother was an optometrist, and he examined him in July 1969. Then he started inquiring into this to see what the causes were. The more we dig into it, the more we realize that it seems to narrow down to the microwave diathermy. Of course, if it does, it has very broad implications, not only for the Bureau, but for everybody out there, too.

I think at this time, I would like to mention that we did a survey in Pinellas County, Florida. George McCall contacted Dick Payne about a cooperative effort with the Bureau. Bill Eden had a hand in this, too, and wanted to find out how these things were used in the area, who was using them and what kind of results they were obtaining.

I think the next slide shows the number of units we inspected.

Type of Equipment	Number Surveyed
Ultrasonic	116
Shortwave	68
Microwave	73

This took two weeks. We sent a team of two people from our laboratories, and they worked with the Pinellas County Health Department and the State inspecting a total of 257 diathermy units.

You will see that in not quite half, but a big portion are ultrasound, 116 of them, shortwave 68, and microwave a total of 73.

The next slide, please.

Operator	Number	Percent
MD	17	8
DO	27	12
DC	22	9
RPT	47	20
RN	24	10
Other	95	41

This will give you some idea of the operators that used these devices. Physicians account for about 8 percent, osteopaths 12, chiropractors 9, registered physical therapists 20, RN's 10, and the other category which is, I think, the most significant one of all, and that is 41. Other includes practically anyone. This can be the wife of these other people. It can be the secretary or a technician.

The other significant thing that in itself is somewhat bothersome to us because we realize that the training they received has probably been second-hand from either the physician or the osteopath or they received their training from the salesman.

The physical therapists had by far and away the most training. As a group, they are the only ones we have uncovered in this particular survey that have had formal training. This is, of course, just one survey that we performed. We intend to do another survey.

I think we can go on to the next slide.

Average Number of Treatments

Owner	Microwave	Shortwave	Ultrasound
MD	4 3/4	3	4
DO	4 1/2	5	7
DC	4	5 3/8	8 2/3
Hospital	8	9	8
N.H.	6 1/2	5	8 2/3
RPT	10 1/2	12 1/2	11 3/4

This gives you some idea of the owners of these devices. Here we average number of treatments by the three different categories. The physical therapists use this much more than anyone else. The physician normally gives up after about four treatments, and the osteopath about the same except for ultrasound. So it gives you some idea of the usage on any one patient.

These are averages. There are extremes on the high side. One particular osteopath exposed himself to, he estimates, thousands of treatments because he has a chronic back ailment. And whenever he feels a little tight, he sits down and uses the unit and gets relief. These extreme cases were not included in the average.

Let's go on to the next slide.

ULTRASOUND

Area	Time	Number	Power W/cm^2
Back	3 to 20	1 to 15	.3 to 2
Neck	3 to 20	1 to 50	.3 to 2.5
Arthritis	3 to 20	1 to 15	.5 to 1.5

MICROWAVE

Area	Time	Number	Power mW/cm^2
Back	10 to 30	1 to 15	50 to 200
Neck	15 to 30	1 to 15	70 to 200
Arthritis	10 to 30	3 to 15	70 to 200

Here is some idea of the different types of treatments that are most common for ultrasound and microwave. We have taken some liberties in breaking these things down. Arthritis includes many other similar things such as myositis and bursitis.

Here are the power densities we are talking about. You will notice ultrasound is actually up in the area of watts per centimeter square. We know almost nothing about the effects from ultrasound and shortwave other than the fact that it does stimulate blood flow. We intend to go into some studies in this area, but right now we have no feel for the bioeffects. We have a better footing on microwaves, and you are aware of some of the limitations on microwave measurements.

Incidentally, in this survey we made no measurements on the ultrasound or the shortwave diathermy units, there was no way we could come up with meaningful measurement techniques. We could heat water but decided it wasn't worth the effort to make the determinations.

So what are we in the Bureau doing about this in determining the extent of the problem? We are getting together with the physical therapists at the Public Health Service Hospital in Boston, and they are helping us quite a bit in getting together an annotated bibliography on diathermy.

They, of course, have worked with this quite some time and are very interested in helping us with it. It is almost in the black magic area. They are not sure what ultrasound, shortwave, microwave does either. Many of the physical therapists are very candid, too, and will admit that some people get relief, some do not.

The type of comments we get from some of the people using the units were: "Well, before I use the laying-on-of-hands on the patient, I give them microwave diathermy for ten minutes." Others will do it in reverse. So it is hard to say what technique is really helping them and whether, in fact, diathermy does as much good as many of them claim. It is kind of an emotional thing. You will find they either really think it is great, or they are not too sure that it is useful.

Many of the bigger institutions like National Institutes of Health, Massachusetts General Hospital and many others rarely if ever use it any more. They think that there are better ways of treating the patients.

I mentioned earlier we are going to do another survey in Massachusetts because Pinellas County has generally an older population. We are not sure if the figures that we have here on uses of diathermy units on the patients are representative of the rest of the country. So we will perform a survey in Massachusetts.

We are going to perform an epidemiological survey of exposed dental patients. I mentioned NIH has given up on it. This is in the physical therapy department. They do use it in the dental department. They use it for something called dry socket and other ailments which apparently gives relief to the patients. The thing that concerns us is it is applied to the face, and the power levels are in the neighborhood of 200 milliwatts per centimeter squared.

We have produced cataracts in rabbits at 80 milliwatts per centimeter squared. We think perhaps that the actual level was more like 40 based on some of the things we have learned lately. This was done, incidentally, by drilling the eyes out of rabbits and placing the probe there.

We are going to review records at the Massachusetts Eye and Ear and look at them over the past couple of years. Hopefully, we will be able to locate other posterior subcapsular cataracts and perform followup studies on them. We will get started with this, we hope, in the coming fiscal year.

We also want to determine the effectiveness of eye shields. There was an article published about three years ago on a specific eye shield. The author said we were about the first one to even inquire about it. He stated eye shields are not being used to any great extent. Unfortunately, he is not even sure how effective the eye shields are. This is something that we intend to do at the laboratory. So we are just groping right now to determine what kind of recommendations we will have to come out with later on.

We are also trying to get together a booklet giving you in concise form what diathermy is and some of the techniques. They use it for practically anything on the body depending on who the operator is. Some of them even use microwave diathermy for treating the sinuses. There is one particular physician in Pinellas County that uses this routine daily on about 30 patients for treating sinusitis, no eye protection or anything.

There is another way we are trying to alert ophthalmologists to this specific type of cataract by having an editorial published in their journal. We also intend to publish similar editorials in the physical therapy journal and other appropriate journals. We might get some exposure there to find out how many people are in fact developing cataracts from this kind of radiation.

I think, to put it in perspective, the color TV versus the medical and dental use of x rays, and the oven usage versus the diathermy are very similar. I think, in fact, diathermy, we find as time goes on, to be a much bigger problem than the microwave oven thing is right now. I expect at this time next year that you, too, will all be "experts" just as we became overnight.

Thank you.

MR. PARKER: Those of you who didn't have a chance to read the Palm Beach Times, I would like to read a portion of Jack Anderson's column.

> "At least 40 cases of cataracts have been caused by insidious microwave radiation from high powered radar equipment, raising fears that similar dangers exist in microwave ovens. The Health, Education and Welfare Department in a private letter to Senator Fulbright has conceded that radar has caused eye cataracts and that microwave ovens are under intense scrutiny.
>
> "Nine of the ovens surveyed were found to emit microwave radiation in range of energy densities where eye effects began to appear among experimental animals, HEW told the Senator. It is worth noting that this same HEW pooh-poohed this column's earlier reports that microwave ovens may pose a threat to eyes under certain conditions."

And I think what Jerry Karches said is probably true that next year instead of talking about microwave ovens, we will be talking about diathermy. Anyone have any questions for Jerry before we move along?

DR. FULLGRABE: Emil Fullgrabe, Missouri.

We have run into some interesting things. Apparently word has spread. And in asking physicians, osteopaths and chiropractors, they almost uniformly now say, "Yes, we have one, but I haven't used it for months."

Another point I would like to ask you about is in our experience, many of the larger high schools and almost all of the college training rooms have these. They use them extensively. Pro football teams and basketball teams, many of the teams use them, though many of these men are well-trained physiotherapists. But they do use them.

MR. KARCHES: The physical therapists are the best trained of all. They do use them quite a bit in the Olympics. The physical therapists there use them.

I had one tell me about an individual who sprained his ankle about two days before the race. He used the ultrasound techniques on his ankle. He came in second two days later.

I also hear stories on the other side that say it did absolutely no good. So quite frankly, I am not sure.

Incidentally, this business of microwave, we are examining eyes of many of the Air Force individuals that have been flying in the EC 121. We know of about 50 of these people that have banded together out in California. We have made arrangements to have the Public Health Service Hospital there examine their eyes to see if there are damages suggestive of microwave cataracts.

MR. KURVINK: Don Kurvink, South Dakota.

I was going to ask you if you ran across a product called the "Vita-lite" which is used in lieu of giving babies transfusions. As near as I can tell, it appears to be either ultraviolet or some other frequency. They place this right above the incubator of children who have RH problems.

MR. KARCHES: I personally have not, no. I do know they are available.

MR. PARKER: John, do you want to say a few words on that?

MR. VILLFORTH: I don't know the details, but I do know we have been in contact with the National Academy of Sciences who is doing a study on this. Our Division of Biological Effects has been collecting some information.

There appears to be some area of legitimate concern. It appears to be used quite frequently in the incubators of premature babies as a prophylactic type of method. The frequency as well as the intensity of the light is being investigated. Maybe some of the other people here might have some information.

DR. STEWART: Stewart, Bureau of Radiological Health, Southwestern Radiological Health Laboratory.

We have looked into this problem just tangentially from the standpoint of laser effects and the potential of causing irreversible damage from light exposures and have contacted Temple University in this regard. An investigator of theirs, Dr. R. C. Sisson has done some work. The interesting thing about this from our standpoint is it looks like there are irreversible functional changes which occur without producing changes such as retinal burns or other visible damage. This is important from our standpoint in terms of setting guidelines and criteria for exposures.

MR. PARKER: Joe Brennan.

MR. BRENNAN: I would like to ask Jerry a question. I notice from your statistics that the number of treatments given by physical therapists is greater usually than the number given by M.D.'s. Does this mean that the physical therapists are setting up their own treatment schedules? If so, do they do it under prescription, or do they do it on their own?

MR. KARCHES: That is a good point. I am sorry I didn't bring that out.

Actually, a physical therapist depends on a prescription from a physician for any treatments. Normally, this is discussed over the phone, and the physical therapist gives him his views on what he thinks is needed, and the prescription is written as such. This is how I understand it.

MR. BRENNAN: And another, if I may. A few years ago, I understand, someone did a study on the incidence of mongolism connected with individuals who, I think, were in the Air Force and worked on radar quite a bit. Does anyone have any information on that?

MR. KARCHES: That is the study there at Johns Hopkins. I think it is an inconclusive study. There are very few cases.

MR. VILLFORTH: This is a study that is sponsored by the Bureau of Radiological Health which you are familiar with. It was a study on congenital malformations. The correlation was made that the father of a mongoloid offspring has some association with radar. I don't think it was a direct study with Air Force personnel, but the parent had had some experience with radar.

This study has raised some question, so it is being reduplicated in an attempt to establish if there really is a correlation in this area. I think we will get some results this summer.

MR. PARKER: Sherwood.

MR. DAVIES: Sherwood Davies, New York.

I have two questions. One, what was the time interval between diathermy treatment and recognition of cataracts?

The second question, how does the calculated measurement you made relate to the current accepted standard in this country?

MR. KARCHES: In the first case, treatments were started in June 1968. In January 1969, he noticed some blurring of vision. It became considerably worse over the next six months when he visited his brother on July 4. At that time, it was diagnosed as cataracts.

The standard in this country that is more or less accepted is 10 milliwatts per centimeter squared.

MR. EDEN: That's occupational, isn't it?

MR. KARCHES: The standard is 10 milliwatts per centimeter squared. I think you are right, it is an occupational. This is what the military uses. The oven manufacturers have been wanting to adopt this, too.

I think this is up for negotiation right now, and it has not been established whether it is to be 10 or 5 or one. It has not been set.

I think for this particular survey that we are going to do, the accepted standard is 10 milliwatts per centimeter squared.

Bob, you better say something about this.

DR. ELDER: That is an occupational exposure, the 10 milliwatts per centimeter squared. The microwave standard for ovens was at 10, and the standard that we hope will be promulgated in the first week in May will be in one milliwatt per centimeter squared at time of manufacture, no greater than 5 milliwatts per centimeter squared throughout life.

If I may, Mr. Chairman, I would like to amplify on that radar study on mongolism because I think it is important that this group recognize the sensitivity of that study. The indication that mongolism was attached to the fathers, people who had been exposed to radar during the war, came off of a well-designed x-ray study in which they were looking at x-ray effects in congenital malformations at Johns Hopkins. When they finished, they pushed the button and said, "Is there anything else you can tell us?" It suddenly came out that a slightly statistical significant number of fathers had been exposed to radar during the war. Now, the study was well designed so it came up with this.

The support we are giving through the Division of Biological Effects is to specifically now look at matched populations of mongoloid children with matched controls. The interesting point that I would like to leave with you is they estimate the numbers that they would have to followup and, of course, their budget. As Mr. Villforth will attest, they had to come back and ask for more money because they have found twice as many cases that they will have to followup on mongoloid children.

This isn't saying their fathers were exposed to radar, but it is interesting that mongolism in Baltimore was 100 percent higher than they had anticipated. I think this is one study that may be delayed because of the number of follow-up cases and it may be another year before we know whether there is a correlation. But it is very sensitive in terms of cause and effect.

MR. PARKER: Our next paper is on the exposure of repairmen of microwave sources by Bill Eden of the Florida Department of Health.

REPAIRMEN OF MICROWAVE SOURCES

William M. Eden[1]

We have had to conduct some studies on the possible hazards in the repair of different things in terms of exposure to repairmen and possibly concurrent with this the exposure to the public or the user or what have you as a result of faulty repair. But we have also gotten into the interest of servicing and testing of, not only used equipment, but new equipment producing microwave radiation.

Preliminary studies have indicated that testing, servicing and repair of microwave devices should be considered potentially hazardous work. Numerous people are involved in such operations involving electronic repair shops, both independent and factory authorized--appliance dealers, radar technicians, aircraft electronics repair and testing, avionics technicians, people in airport radar repair, military radar for tracking, scanning, search, guidance, ranging and so forth, telephone and TV communications and other uses, including the power companies, the oil and gas pipelines, the plastics and the woodworking people.

On-site repairs are made with the device in place, of course, but much of the testing, servicing and repair are performed in-plant and at the work bench within confined spaces and involving other personnel besides the repairmen.

A recent report by Dick Thompson of Eastern Test Range experiences with the tracking radar systems there indicated that there was leakage from the waveguide in one of the systems that was due to inadequate repair, I would imagine, or some servicing. And it had resulted in excessive microwave exposures to operators within control rooms.

A review of procedures involving test stands for new Klystrons at a microwave tube manufacturing plant in Florida indicated potential exposures to personnel.

The most significant study we have conducted has involved microwave oven repair. Those of you who were at the Health Physics Society Midyear Symposium will have to bear with me in terms of reporting this study.

As you can understand, microwave ovens are becoming increasingly popular. Our attention was drawn to this fact by the request from local health officials in the State of Florida. Responsible microwave oven users have expressed concern for safety in operating ovens currently in use.

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[1] Radiological Health Program, Division of Health, Florida Department of Health and Rehabilitative Services.

The manager of a self-service food vending operation in the employee's lounge of an industrial firm expressed concern and requested advice regarding the illumination of hand-held fluorescent tubes used in checking the microwave ovens that are provided for his customers' use. He had been told that the illumination was an indicator of microwave leakage which was harmful for persons near the ovens. A housewife and a hospital dietitian had requested advice regarding the safety of microwave ovens after reading articles appearing in the newspapers and food journals. These requests for assistance emphasize the need and accelerated our plans for providing a program of evaluation of microwave ovens in use.

Our study in this regard has been reported previously at the APHA annual meeting. Although there was indication in the literature of oven maintenance by owners of the devices, only two reports were found of injuries to repairmen. Information gathered during our study of microwave ovens in use indicated that repairing microwave ovens presented a greater hazard potential, especially to the unwary.

We found that owners attempt to repair their own microwave ovens, domestic and commercial. Restauranteurs have stated that repairs by factory authorized service firms are often delayed and costly. Officials of food vending firms contacted in Florida stated that they install, service and repair microwave ovens utilized at their food vending outlets. None of these indicated receiving any formal training related to microwave hazards.

Some have emphasized that microwave detection equipment was scarce and too expensive to be justified. The expense of the available detection equipment was related by a representative of the National Automatic Merchandising Association.

We learned from microwave oven owners, dealers and distributors that radar technicians, electronics servicers, electrical appliance repairmen and restaurant equipment suppliers service personnel attempt to repair domestic and commercial model microwave ovens. Only a select few of the microwave oven manufacturers have established factory authorized repair service conveniently located for owners in Florida.

Formal training regarding the hazards of microwave exposure is rare for microwave oven repairmen, and microwave detection equipment has been nonexistent in their shops. Fluorescent tubes and neon lamps have been used to indicate microwave leakage. Of course, ammeters are available to indicate flow of current in a magnetron, and a screwdriver was used to locate an arc from microwave leakage. Some people have told me this is pretty scientific, but no quantitative measure of microwave energy released from the oven to the surrounding environment had been made. It seemed the attitude is "What you don't know doesn't hurt you."

We felt that further evaluation of working conditions was warranted. It was our desire to utilize available instrumentation used to detect microwave energy to determine the levels of leakage at the repairman's position during oven repair.

Scheduling of such studies was rather difficult mainly due to lack of cooperation maybe from the oven repairmen. Tests were made as opportunities were afforded by interested and cooperative repair shop owners. There was no attempt made to determine the frequency and the nature of work performed per model of oven nor time spent per day energizing magnetrons nor measuring distance between magnetrons and body areas. It was noted that microwave ovens are not always repaired at waist high workbenches.

I will now give you an indication of what we found.

In the repair shop we visited, we saw ovens awaiting repair, not only on the floor, but on low platforms. Observing the repairman in a typical work location, the top of the oven is below his crotch.

The oven he was working on was operated with a Chinaware bowl of tap water in the cavity as the load. The detection limit of 20 milliwatts per centimeter squared was exceeded on the power density meter at approximately two feet from the nearest magnetron as you might be able to observe in this squirrel cage.

The repair shop owner sought to verify the existence of microwave energy. He didn't trust our meter. He wanted to verify it outside of this magnetron enclosure by creating an arc between a screwdriver and the copper tubing in the water coolant line that exists between the magnetron and the heat exchange radiator.

He produced further evidence of microwave energy by adjusting the bolts, retaining the magnetron enclosure to the oven frame or chassis. Tightening the bolts reduced the power density level detected while loosening the bolts increased the levels to previous measurements. He stated that the oven was received for repair in this condition.

We did look for ionizing radiation on this particular oven with Victoreen Model 440 RF, and we were unable to detect this. So I don't believe it influenced our measurements.

An earlier version of this particular oven was checked for operability in another repair shop. The load consisted of six ounces of tap water in a styrofoam cup. The repairman had removed the rear panel, tripped the cabinet panel interlock switch, set the timer and pressed the operating button in order to check the magnetron for operability. Although the red light indicated that the oven was cooking or operating, there was no evidence that the magnetron was operable until a popping noise was heard inside the oven and the power density meter indicated full-scale deflection on its maximum scale of 200 milliwatts per centimeter squared at a position between the rear of the oven and the repairman who at this time was standing about two feet away.

The magnetron was apparently sporadic in operation since the power density meter responded only twice during this checkout procedure. The repairman stated he had noticed reflections of the magnetron "flash" within the oven during that time. The repairman removed the magnetron assembly and noted that the metal gasket material was bent out of place at the bottom of the joint between the magnetron assembly and the waveguide leading into the oven cavity.

The electrical components are pretty obvious through the open area through the rear of this oven. Some ovens of this model have been observed with hardware cloth over this opening probably to prevent the insertion of a person's hands into the high voltage area.

The detection limit of 20 milliwatts per centimeter squared was exceeded on the power density meter at the open area during operation at a restaurant. This was observed during testing of ovens in public food service establishments as previously reported.

The area behind the oven is designated as the "coffee break" for employees. And humorously, we think if a fellow stood behind this long enough, maybe he would be smoking. It is known as "the smoke and coffee break."

The owner stated that the oven had been repaired within the previous six months.

Here we saw evidence of the possibility of a person standing behind a similar unit.

Power density level of five milliwatts per centimeter squared has been measured at the openings at front top corners of this model oven when the door was closed during test for leakage. It is believed that leakage at such positions as this on this particular model is due to faulty repairs.

We have observed the same oven with the cavity removed, the oven cavity removed. One can look right straight into the open magnetron.

We have had a repairman claim that he has been injured by operating an oven in this condition. This has not been verified, but I can well imagine that it could be if he was foolish enough to do so very long. A repairman, when he removes the oven cavity to make some repairs, can view the bare magnetron.

Another example of inferior construction and possible error in repair was found in an oven we observed. The power density meter indicated levels exceeding 20 milliwatts per centimeter squared at two feet in front of an oven in use at a food vending facility. It was obvious that someone had inverted the pressure plate which serves as an integral part of the door seal and the grid or screen for the viewing, leaving an inch gap in the door seal across the bottom of the door.

I don't have a picture of that, thank goodness. The repairman that was there repaired it before we could photograph it. We did well to make measurements.

If you stack these things up, you are getting it in the eyes as well as down below, if you have these conditions existing.

You may say, "Well, the repairman might be exposed, but certainly not the people using it." We have observed one oven existing in a restaurant with the cabinet removed mainly for ventilation.

One of the purposes for this report is to alert public health officials to the need for evaluating neglected aspects of microwave oven surveys. Testing of microwave ovens in use must necessarily include surveys of all accessible external areas for microwave leakage to properly control exposure to users and other personnel near cabinet openings.

I would also be bold enough to say that those coming off the assembly line should be done in the same way. We certainly would not like to see a brand new one coming out with similar conditions.

It should also seem evident that repair operations need evaluating for hazardous conditions and practices. Warnings are in order for prospective repairers. An understanding of microwave hazards and means to prevent needless exposure are essential for workers involved in microwave oven repair.

Consideration should be given to providing the necessary training in safety precautions, utilization of microwave detection equipment, protective clothing, and eye shields for persons involved in microwave oven service and repair. Licensure of repairmen and certification of repair shops should elevate standards of protection and require higher quality of repair for the consumer.

The development and use of personnel and area monitoring for radio frequency radiation and the provision of periodic physical examinations with emphasis upon thorough eye evaluations for all microwave oven repairmen should provide information related to microwave exposure.

Further hazard reduction could be provided by shielding and warning labels for magnetron tubes. Repairmen are subject to exposure from the open end of these magnetron assemblies when they are activated to say nothing of this open magnetron itself.

Microwave oven repair should be recognized as hazardous work. Persons attempting to repair microwave ovens are subject to acute damage from sudden, high levels of exposure. Power density measurements around microwave ovens with outer cabinet panels removed indicated potential exposures in excess of currently accepted radiation protection guides for radio frequency.

Repairs are attempted by microwave oven owners, radar technicians, electronics servicers, electrical appliance repairmen, restaurant equipment suppliers service personnel and food vending firms. There are only a few manufacturers represented by authorized repair firms, and their service is often delayed and costly.

Corrective measures should include the provision of adequate training regarding microwave hazards, utilization of microwave detection equipment, protective clothing, and eye protection. The development and use of personnel monitoring for FR and the provision of periodic physical examinations including intensive eye studies for all microwave oven repairmen would provide indications of exposure levels. Shielding and warning labels for microwave tubes would provide further hazard reduction.

MR. PARKER: If anybody has any questions, we will ask them to field a couple before we go on to the next paper.

MR. EDEN: I do have copies of the paper that was presented at the Health Physics Society Mid-Year Symposium at Louisville if anyone didn't get a copy there.

MR. McHARD: McHard, Oklahoma.

Did you and your personnel take any protective steps during these surveys, particularly with regard to the eye?

MR. EDEN: Thank you for asking this. I think it is very pertinent. I mentioned the testing of new and used equipment and failed to stress the point that maybe some of these poor guys like us that are testing it for leakage need some of the same protection. We did not.

I think this is another good reason for some personnel monitoring such as we enjoy with ionizing radiation. It is very difficult to get some measurement of what exposures may be with nothing more than a meter.

MR. STEIN: Lee Stein of Delaware.

You mentioned the RF dosimetry. How do you propose to do this?

MR. EDEN: I would like to propose that somebody look at it. I have heard that there is some study going on. I am not sure what the advancements are, but we would certainly appreciate it.

MR. PARKER: Lee, that was one of the recommendations of last year's Conference that the Public Health Service immediately initiate research into this area. Unfortunately, funds were not forthcoming, and I don't think they have started yet.

The next paper is back to the Federal Government, the Bureau of Radiological Health, Harold Stewart from the Southwestern Radiological Health Laboratory on Lasers and Laser Hazard Evaluations.

LASERS AND LASER HAZARD EVALUATIONS

Harold F. Stewart, Ph.D.[1]

Since the advent of the laser in 1960 much time and effort has been devoted to research, improving laser technology and seeking applications for the laser as a tool. In the 1960's most of the research and applications were supported by and thus directed toward military needs. In the late 1960's, however, the search for civilian applications was intensified. This new emphasis was recognized in the theme of the Laser Industry Association's 1969 annual meeting--"Lasers Enter Year One of Applications Era." (1)

With this change in emphasis and as the uses of these devices expand, the problem of exposure to the general public to potentially hazardous emissions will increase and become more apparent. This paper presents a general discussion of the most common lasers in use today, trends of the laser market, some of the potential applications being considered and developed, and the potential hazards and control of laser emissions.

Sources of Laser Radiation

Many different types of lasers are now available in a wide range of power or energy and wavelengths. The powers available range from fractions of a milliwatt to gigawatts, and the wavelength emitted by the different laser types ranges from the ultraviolet through the visible and into the far infrared. Similarly, pulse durations run from picoseconds to continuous (cw) output. Thus, it has become necessary to discriminate between the various types of lasers and the different hazards associated with them. These may be divided into the following categories: (1) high-energy lasers capable of producing hazardous diffuse reflections, (2) small cw lasers with visible emissions, (3) semiconductor lasers, and (4) infrared molecular gas lasers such as carbon dioxide units. Laser types in common use or likely to be used are listed in Table 1.

The optically pumped, solid-state laser, which characteristically produces high-intensity pulsed emissions, is generally most familiar because it was the first laser type to be operated in 1960 by T. H. Maiman. The solid-state laser is referred to as being an optically pumped laser because the energy for exciting the atomic electrons is provided optically by a light source such as a xenon flash tube. Optically pumped, solid-state lasers are usually associated with pulsed operation and currently offer the highest peak power. They include Nd:glass, Nd:YAG and ruby lasers. The YAG is one of the most promising optically pumped, solid-state lasers on the market today and shows promise to exceed the ruby

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Table 1. Laser Medium and Operating Wavelengths

Medium	Operating Wavelength (nanometers)	Operation	Type	Typical Power (watts)
Ruby (Chromium) $Al_2 O_3$	694.3	Pulsed	Solid State	100kW-10GW
Nd: glass	1060.0	Pulsed	Solid State	100kW-10GW
Nd: $CaWO_4$	1060.0	Pulsed	Solid State	10kW-10mW
Nd: YAG	1060.0	Continuous	Solid State	100mW-100W
Helium-Neon	632.8	Continuous	Gas	100μW-200mW
Argon	457.9 - 514.5	Continuous	Gas	100mW-10W
CO_2-Nitrogen-Helium	10600.0	Continuous	Gas	1W-10kW
Gallium-Arsenide	840.0 - 900.0	Continuous	Semiconductor	2W
Rhodamine 6G	Tunable-red to green	Pulsed	Dye	10kW

as the most common type of solid-state laser in the future. The active element in a YAG laser is a Yttrium-Aluminum-Garnet crystal containing neodymium. The cw YAG laser is optically pumped with a tungsten lamp and normally produces a continuous, not pulsed, infrared output. However, by the use of doubling crystals in the laser, the emitted wavelength is halved and other colors of light are produced. For example, the invisible infrared light emitted by the YAG laser, 1.06μm, can be passed through a doubling crystal so that it emits visible green light, 0.53μm.

Another type of laser which shows promise for the future is the tunable dye laser. These tunable lasers have many potential applications. For example, they will increase the ability of spectroscopists to study surface trace materials. Continuous wave (cw) gas lasers are available with an output range from the milliwatts to several watts. The most common gas lasers in use today are the helium-neon, helium-cadmium, carbon-dioxide and argon lasers. For low-power applications such as demonstration and alignment techniques, and instrument applications where high optical quality, stability and visible output are required, the helium-neon (He-Ne) gas discharge laser is generally used. When higher power levels are required (one watt to several watts) argon, krypton and frequency-doubled Nd:YAG are used. The CO_2 laser with an infrared emission at 106.0 nanometers with output power on the order of kilowatts is used for such applications as welding, machining and cutting. Lasers of the helium-neon type have a direct relationship between the length of the glass tube containing the gas and the maximum amount of power emitted by the laser in the form of light. A one-milliwatt helium-neon laser, for example, is approximately one foot in length whereas a four-foot helium-neon laser will produce a hundred milliwatts. Thus, when an individual encounters a helium-neon laser, he can get an order of magnitude approximation of the output power simply by looking at the physical length of the laser itself. On the other hand, argon gas lasers of comparable length can emit several watts of power at wavelengths in the blue-green portion of the spectrum.

The injection or semiconductor laser is typified by the gallium-arsenide (GaAs) laser with an emission wave length of 840.0 nanometers. Unique advantages are small size and high efficiency. Output powers range up to two watts in continuous operation and several hundred watts in pulsed operation. The efficiency of this type of device is approximately 20 percent versus 1 percent to 3 percent in solid-state lasers and slightly less than 1 percent for the visible gas laser.

At the present time it is possible to produce ultraviolet emissions with both gas and semiconductor lasers. Semiconductor lasers emitting in the ultraviolet use zinc sulfide and zinc oxide and attain outputs of one to two watts (2). Ultraviolet emissions produced by continuous operating gas lasers occur at 332.4 and 337.8 nanometers for singly ionized neon and 350.7 and 351.1 nanometers for doubly ionized krypton and argon, respectively.

Laser Technology Expansion

Laser applications technology has expanded in many directions during the past decade. In the past, military applications have dominated the laser business; now, however, much attention is being given to civilian applications. The potential for such applications seems almost unlimited. The Laser Focus survey of 1969 showed that civilian sales and services constituted 36 percent of the laser market and is expected to comprise about 48 percent of the market by 1972 (3). If this trend continues, the civilian segment should equal or exceed the military market within the next year or so. A projection made by the Robertson and Associates firm of engineering, marketing and investment consultants, predicts a 650 percent increase in the laser industry by 1977. (11)

While today, laser emissions do not constitute a widespread environmental hazard to the eye, such may be the case in the near future, particularly in view of the large expansion of sales of laser systems in the commercial market and new applications developing in many areas. This tremendous expansion in a technological field with a demonstrated hazard potential gives our experimental, hazard evaluation, and control programs a real sense of urgency.

Laser Applications

The primary areas of interest in the field of military applications include rangefinders, illuminators and laser guided bombs, missile guidance and communications. For the commercial market, the applications developing currently include space communications, projection systems, displays, holography, range finding, alignment techniques such as surveying, tunneling, mining, etc., welding, die punching, computer memory storage devices, electronic circuit welding, spectroscopic analysis of surface trace materials, high temperature analysis of materials, various servo control systems involving light absorption, scattering and transmission or reflection of light, microscopic illuminators, high-speed photographic systems, laser ring gyroscopes, oceanographic sounding, detection of atmospheric turbulence and precision balancing of high speed rotational equipment such as turbines and centrifuges.

Some applications projected as million dollar markets include construction alignment, ranging, spectroscopy, distance measuring, data processing, materials processing and meteorology. Other applications which are being developed that would require lasers numbering in the tens of thousands include a system for showing holographic recorded films on home television sets, a system for customer identification or credit card validation (a prototype of this system was displayed at the Smithsonian Institute laser exhibit which opened January 21, 1970), a system for showing holographic motion pictures, and the use of lasers as light sources for movie and slide projectors (3). These applications are being worked on by RCA, ICV, Inc., CBS and Sonovision, Inc., respectively.

All lasers have the potential for causing damage to individuals. Certain of these applications, however, can potentially constitute an environmental hazard to the general public. These include range finding in commercial airports and on military reservations, satellite tracking, air turbulence and pollution studies, laser illumination of art exhibits, holographic public displays and projection systems. There are many other potential applications involving exposure to the general public which may be exploited in the near future such as use of laser spotlights and decorative lamps, and the use of injection lasers in display panels. In the future, lasers may also be installed in public places to count traffic and scan railroad tracks for potential obstructions, or be used to project images of traffic information of super highways. In addition, lasers are being constructed by high school students, used as pointers for lectures and demonstrations and applied to illumination problems which involve art galleries and three-dimensional displays.

Thus, it is important that potential hazards be analyzed and methods for controlling them developed. Early action could result in substantial manpower and cost savings in the implementation of safe operational guidelines.

Hazard Evaluation Guidelines

The evaluation and control of such potential laser hazards must be related to the potential of laser emissions to cause biological damage. Thus, any suggested exposure guidelines or specifications on performance standards must take into account and use reported biological data as guidance in their development and in development of precautionary measures for the reduction of hazards resulting from the use of laser systems.

The threshold studies that have been conducted with visible laser light have been concerned with the energy density which will cause visible retinal lesions. The retina is of critical concern because the lens and cornea of the eye focuses the incident visible power density upon the retina resulting in an energy density on the retina which is about 10^5 times greater than the level incident at the cornea.

The most extensive work that has been done in determining threshold intensities causing visible retinal lesions has been performed by Dr. Ham and his colleagues at the Medical College of Virginia on the retinas of rabbits (4). Figure 2* shows a plot of his data along with that of other investigators (4,5,6,7). It can be seen from the curve obtained by Ham for an 800 micrometer spot size on the retina that the threshold for visible retinal damage depends on the time of exposure of the eye to laser pulses. For a Q-switched pulse of 25 nsec, the threshold for observable damage is approximately 0.08 J/cm^2. For a non-Q-switched pulse slightly less than one millisecond, the threshold for observable damage is about 1 J/cm^2. For exposure times of seconds, the threshold is about 6 J/cm^2. The dashed curves are data obtained by Ham for three different spot sizes using carbon arc and xenon light sources (white light). These curves are all in close agreement with the curve for ruby laser light.

The lower curve in Figure 2 was obtained by Kohtiao, et al, and was drawn using only three data points. However, it can be seen that this curve generally agrees with Ham's data within an order of magnitude. The two vertical lines on the left of Figure 2 are data from two investigators (Ham and Bergqvist) using Q-switched ruby laser pulses focused to varying spot sizes on the retina. Northeastern Radiological Health Laboratory has also reported a threshold for a 100 micrometer spot size of 380 J/cm^2 for a one-second exposure. These indicate a definite dependence of threshold damage on spot size. We have, then, two major criteria for determining threshold energy levels--spot size and time of exposure.

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*Not included in this publication.

In reviewing the literature, we have found that one of the weaknesses in most of the reported results was the lack of complete reporting of experimental conditions and necessary parameters such as spot size and, most importantly, how it was measured, power or energy density on the retina, exposure time and the criteria used for determining visible retinal lesions. Most exposure guidelines such as those suggested by the American Conference of Governmental Industrial Hygienists (ACGIH) for ocular exposure criteria at the cornea are derived by extrapolating visible retinal lesion thresholds to the minimum possible retinal lesion spot size (typically approximately 20 micrometers in diameter) and then to the corresponding irradiance at the cornea (8). Figure 2 also plots the guidelines suggested by ACGIH for ocular exposure at the cornea times 10^5 (a typical optical gain) for a rough comparision with the experimentally determined retinal lesion threshold values reported by the various investigators. Figure 3* shows the fractional transmission to, and absorption by, the retina as a function of wavelength (9). This information must be taken into consideration when trying to compare retinal lesion thresholds using lasers emitting different wavelengths. This curve shows that there are two peaks near the infrared region, the larger one at 1,100 nanometers and the smaller at 1,300 nanometers. Wavelengths shorter than approximately 400 nanometers are absorbed primarily by the outer layers of the cornea. Thus, ultraviolet laser beams will produce corneal damage rather than retinal damage. The wavelengths of the infrared region longer than 1,400 nanometers do not penetrate the ocular media and, therefore, also produce corneal rather than retinal damage. Much work remains to be done in evaluating the hazard to the eye, which is considered the critical organ.

Laser Hazard Control

The control and evaluation of laser hazards can be divided into three categories: the laser design control, the environment, and the personnel. Each of these categories will be discussed separately.

Effective Controls of the Laser Device. Careful consideration should be given to "built in" safety features during the design, construction and installation phase of laser use. The mechanism for requiring that this be done is Public Law 90-602. Effective controls of the laser itself may involve, for example, enclosing the entire laser system within opaque material as is done in most laser microwelding and drilling units in industry today. This approach, of course, is not practical for most laser systems because it is the laser beam itself that must be utilized in the laboratory. A second example, in terms of laser control, is that in some applications it is possible to reduce the laser's output radiance to a safe level without interfering with the utility of the device. This approach might be useful with low-power lasers used for educational and demonstration purposes. Reduced irradiances will reduce the potential hazards. This approach may become practicable in many other applications as detector technology advances. A third approach is to include controls in the laser system itself such as interlocks on doors for high-powered systems, key switches on low-power lasers used in high schools for education and demonstration purposes, requiring that high-power pulsed devices be so constructed that they cannot fire accidentally.

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*Not included in this publication.

Charge storage devices must be equipped with bleeders. A fourth method in controlling potential hazard is in the utilization of less hazardous infrared wavelengths for some applications. At the present time, this is limited by detector technology.

Controlling the Laser Environment. The use of lasers in the environment can be divided into three categories: (1) lasers which are used in the open laboratory, (2) laser systems which are used in "open air" applications, and (3) lasers which are totally enclosed. In the third case, total enclosure can be accomplished by the effective design of the laser as discussed under effective controls of the laser. Thus, only the first two categories, in which total enclosure of the light path may be precluded, will be considered here.

In the case of lasers that are used in the laboratory, environmental controls include the use of limited-access rooms and areas to prevent accidental exposure to personnel or, when this is not practical, the use of backstops and shields to exclude the beam from occupied areas and well-illuminated laboratories. When there is risk of injury to the eye due to potential scattered light levels, the use of protective eyewear should be mandatory. In the past, it has been common practice to use flat, black paint on the walls of laser laboratories to reduce reflections. This results in reducing the ambient light levels and causes other problems to arise such as glare and eyestrain. The lower ambient light levels also result in dilated pupils which permit greater laser energy to enter the eye. A more desirable approach is to use white, diffused walls with black, absorbent, diffused target areas. When using white, diffused walls the ambient levels can be increased resulting in smaller pupils which permit less laser energy to enter the eye. This can provide a safety factor of approximately ten. Although this is worthwhile and significant, it does not constitute a method, in most cases, of changing the hazardous situation into one that is no longer hazardous because the protection required is usually several orders of magnitude larger. This requires either the use of protective eyewear or, in some cases, closed installations with door interlocks and other fail-safe methods. A study of the use of lasers in the United States conducted by the U.S. Public Health Service revealed that warning buzzers were used in very few installations and only four percent of laser operation areas had such devices. In addition, only five percent of the areas were equipped with a communication system between the isolated laser room and non-hazardous laser areas. Warning lights were used to indicate a laser hazard area in only 19 percent of the laser operating areas (10).

In the second category, where laser beams are propagated through free space, the major potential hazard is that of specular and diffuse reflection from objects in the beam. Examples of these applications would be communications, ranging, fog detectors, smoke plume monitors and tracking systems for satellites. These open-air applications require special thought because they involve safety, not only of operating personnel, but also of unwary members of the general public.

Personnel. The prevention of unsafe acts by personnel can be achieved primarily by the application of good administrative procedures, education, training and careful supervision. One of the needs is to educate personnel to discriminate between the various types of lasers and the different hazards associated with them. For example, high-energy, pulsed lasers are capable of producing hazardous diffused reflections, whereas with small semiconductor lasers and small visible lasers used for alignment purposes, potential exposure to the primary beam and specular reflections present the most common potential hazard. On the other hand, lasers operating in the far infrared, such as carbon-dioxide units, present potential hazards to the cornea of the eye rather than the retina as noted earlier. A program of education of personnel concerned with laser hazards is an essential and necessary part of the total hazard control effort.

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MR. PARKER: Did anyone have any questions of Harold?

MR. SCHOFIELD: Schofield, Virginia.

Has anybody looked into the possibility of using Federal Hazardous Substances Labeling Act to get control over the labeling in interstate shipment of these laser kits for school use? I know of a case in Virginia where this was used in a somewhat round-about way to control one of these devices for purifying the air by producing ozone. But it was basically a mechanical device.

DR. STEWART: I am not aware of these myself.

MR. SCHOFIELD: Do you think it has any possibility?

DR. STEWART: It may have some possibility of use.

MR. PARKER: We are going to start now with the last paper of the first session. The last paper will be presented by Mr. Ron Shearin of the Southeastern Radiological Health Laboratory. The title of his paper is "Radar Hazards Evaluation."

RADAR HAZARDS EVALUATION

Ronald L. Shearin[1]

To qualify that just a little bit, I am with Southeastern, which is correct, but I am located physically at Cape Kennedy. I am liaison officer between the Air Force and the Public Health Service. This represents a little bit of what I have been seeing as I look over the Air Force's shoulder in the conduct of the surveillance of the radar systems on the Air Force Eastern Test Range.

This is a range that extends all the way into the Indian Ocean from Cape Kennedy. So it is quite big, and quite a number of radar installations are on it.

Radar Hazards

Electronic technology in the last 25 years has exhibited a growth chart that looks like the power chart of a supercritical reactor. Radar applications, design, and utilization have grown accordingly. In the American way of doing things bigger and better, we have also made bigger and better radars. The radiative power capability has increased to over 400 times what it was 30 years ago. Some of our radar installations are licensed by the FCC to operate to 10-15 megawatts.

In addition to power output, the numbers of installations have also increased. The Electromagnetic Compatability Analysis Center reports as of July 1969, 2991 fixed radar installations in this country. In Florida alone we have 365 installations. Although this number is not impressive to microwave oven surveyors, it is important to recall that one of these units can radiate excessive power density through large volumes of free space. A typical defense surveillance radar might have a 450 foot radius to the 10 milliwatt/cm^2 power density line in the center of the radar beam. As it operates within a hemisphere, it could radiate a power density in excess of 10 mW/cm^2 within a volume of space of about 95 million cubic feet. Fortunately, only a small fraction of this volume is accessible such that human exposure can occur.

Recognize, however, that a few radar installations can provide a lot of hazardous environment. Obviously, it is necessary to perform a hazards evaluation of each and every installation in its operational state and then impose restrictions to control the hazards.

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[1] Aerospace Liaison Officer, Southeastern Radiological Health Laboratory, Public Health Service.

Surveillance and Control of Hazards

Most of the radar units are owned and operated by the Federal Government with the most powerful owned and operated by the military. Since the military has been the prime operator, they have been the prime developer of microwave hazard evaluation techniques. Their evaluation is directed towards three problems:

1. Hazards to Personnel
2. Hazards to Explosive Ordinance
3. Hazards to Fuel and Propellant Handling

The Survey

In order to maintain an effective hazard control program, it is important to begin the assessment of the hazard problems of a radar installation while the installation is still in the planning stage. Many hazard problems can be solved by slightly altering the installation siting or design before construction begins. This is particularly important for solving problems arising from the interaction with surrounding facilities. Power density values can reasonably be predicted by near and far field calculations using the design parameters. Often, however, a combination of reflective surfaces from topography and structures create reinforcement reflection such that elevated power densities might occur. These are identified best by an experienced microwave hazards evaluation engineer who can "sense" such anomalies.

Following the construction of the installation, a set of stringent operating restrictions are placed on the unit prior to the actual site survey. This is done to allow the unit to be brought up to an operational status so that the final emission parameters are firmly established.

Finally, the actual site survey is performed. The surveyors arrive with a set of predicted power density values already calculated and an extensive knowledge of the facility and the surrounding area. Their equipment includes two power density meters with the proper antenna horns for this radar frequency, RF shielded hoods or suits, two walkie-talkie radios, a tape measure, perhaps a beam finder such as the Sperry Detector, a means of elevating the surveyor into the radar beam, and an RF shielded x-ray dose measuring device.

The first step is to survey the facility itself. X-ray measurements are taken in the vicinity of RF power generating components and other areas where high voltage exists sufficiently to produce x rays. The measurements around the klystron, for instance, are always taken with the RF drive on so as to create the conditions of maximum x-rays production.

The next step is to look for RF leakage around the RF generator and in the wave guide apparatus leading to the antenna feed. Interlock and access controlled procedures are evaluated for areas about the antenna in much the same way as one would evaluate an accelerator installation.

The next step is to evaluate the open space environment about the antenna. Here the radar antenna is oriented to a fixed azmuth and low evaluation, usually zero. Communication is established between the operator and the outside surveyor. The surveyor finds the beam center and begins a series of measurements to determine the center beam power density as a function of distance. RF shielded protective clothing and selected operating parameters are used to insure that the surveyor is not exposed to excessive power densities. The objective is to determine the variation of power density under optimum conditions allowed by the design duty cycle, from the antenna out beyond the 10 mW/cm^2 measurement. Most of these measurements are made in the near field. Obviously, frequency and polarization must be considered in making these measurements.

Now it is time to orient the antenna in those directions which have been previously chosen as possibly causing unacceptable power densities by reflection. Other areas are also checked where the beam can radiate excessively and access may not be controlled such as nearby rooftops, power poles, and other elevations.

The total results of the survey are then reviewed and recommendations are made as to restraints that must be employed to eliminate or control the hazards. Hazardous areas if not eliminated, are marked. Mechanical and electrical "STOPS" are installed in the antenna control system to prevent orientation of the antenna in positions which will cause problems. Thus, a RF radiation control program is tailored to the individual installation. Such a program, if effective, does not need to be changed with time as long as there are no modifications to the system or changes in nearby structures.

Of special note is that out of the numerous radar installations on the Air Force Eastern Test Range, none of these had to give up any assigned mission capability to meet the imposed safe operating requirements. The Air Force Eastern Test Range has not found it necessary to expose anyone to power densities greater than 10 mW/cm^2.

Radar and Public Health

I am personally convinced that radar installations pose no great threat to public health, so long as an effective program of survey and control is implemented for each site. I do believe that every radar installation capable of emitting power densities that would be considered hazardous to humans should be required to demonstrate to a competent authority that an adequate control program has been provided.

A final point must be made to persons proposing to perform microwave surveys on radar installations. Such a survey can only be done in a meaningful manner with the cooperation and probably the participation of the operating agency. Radar measurements can only have meaning when done by knowledgeable experts. Such measurements are far from being meter reading exercises. The surveyor has to have experience in working with polarized beams, reflected energy, and the many operating parameters which are available to the radar operator. A microwave surveyor of radar systems has to have significant field experience before he can be turned loose to make and report meaningful and reliable measurements.

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Acknowledgements

Pan American Airways' Environmental Health Section of the Cape Kennedy Air Force Station furnished material, slides, information and guidance for this report.

MR. PARKER: Thank you very much, Ron.

If there are no questions, we will close this session.

APPROACHES TO THE CONTROL OF ELECTRONIC PRODUCT RADIATION (continued)

PANEL: USER QUALIFICATION

Moderator: Robert Frankel[1]

MR. FRANKEL: Good morning. My name is Bob Frankel. I am with the Federal Bureau of Radiological Health. I am very happy to be here.

As many of you recall at the Health Physics Mid-year Topical Symposium in Louisville, Kentucky, I didn't quite make it through the entire meeting. I came down with bilateral pneumonia. I had to be dashed out to a hospital. But I recovered. And as I said, I am very happy to be here today enjoying the climate and the activities in and around Palm Beach.

Now, let's get to the topic at hand itself. We are going to be talking about user qualfiications of ionizing radiation in the healing arts. Once the decision to take an x ray is made, the dose that is delivered to the patient is really dependent upon several factors:

The first of which is the type and speed of the recording system.

The second of which is the equipment itself.

And the third of which are the qualifications or competency of the people who use this equipment.

The type and speed of the recording system itself is not necessarily directly germane to our discussion this morning, but, indeed, may become part of the user qualifications as time goes on.

Insofar as equipment is concerned, I expect to see as time goes by, further advances in equipment. Concerning the existing equipment that is out in the field right now, you fellows in the States have really been doing an outstanding job in conducting surveys. It is because of you, mainly, that we see the improvement of the existing equipment out in the field; and we know this improvement will continue.

However, insofar as the user qualifications are concerned, the response by the States has been somewhat more limited. The first program to have licensing for a user was the Commonwealth of Puerto Rico. The Commonwealth of Puerto Rico's program licenses only radiologic technologists.

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[1] Radiological Health Representative, ECA, DHEW Region III, Philadelphia, Pennsylvania. Formerly Deputy Radiological Health Representative, ECA, Region II, New York, New York.

On the mainland, we have the State of New York which also licenses only radiologic technologists. Following New York State was the State of New Jersey which, besides licensing radiologic technologists, also licenses dental x-ray technologists.

And, of course, recently we have had developments in California pertaining to licensing or certification, rather, of all users of ionizing radiation in the healing arts. So I believe that this program this morning will be quite interesting.

Now, as for ground rules, I thought that you should have the opportunity to hear all of the speakers present their short presentations and, following that, the speakers will respond to questions from the audience and, indeed, from each other as the case may be. So, please, we will let all four speakers first give their presentation. Afterwards, they are fair game for any questions which you may have.

The first speaker on the panel this morning will be Mr. Richard Olden, R.T. Mr. Olden is on the Board of Directors of the ASRT and is the Administrative Assistant in Radiology, Johns Hopkins University Hospital.

Dick, I hope you also have an opportunity to tell us a little more about the ASRT and how it relates to the ARRT. I think there is some confusion here.

Mr. Olden.

LICENSING X-RAY TECHNOLOGISTS

Richard Olden, R.T.[1]

In going around the country, I find that there is quite a variance in opinion as to what organization I represent and what organizations represent me. I find this is true, not only with Public Health Service people, but particularly true with technical representatives of equipment and film manufacturing companies.

I would like to very briefly explain to you what the situation is. The American Registry of Radiologic Technologists is jointly sponsored by the American Society of Radiologic Technologists and the American College of Radiology. Its primary mission is to examine and to certify eligible candidates in x ray, radiation therapy and nuclear medicine technology.

In addition, it encourages the study and elevation of standards in each of the three disciplines in radiologic technology. The examination of the ARRT is based on the 2-year basic minimum curriculum initially developed by the ASRT with the endorsement of the American College of Radiology and the approval of the Council on Medical Education of the American Medical Association.

Membership in the ARRT is restricted to four technologists, appointed by the American Society of Radiologic Technologists and four radiologists appointed by the American College of Radiology. Other than that, there is not any membership in the ARRT. It is independently incorporated in Minnesota, and the home office of the Registry is in Minneapolis.

The American Society of Radiologic Technologists is the professional society of radiologic technologists. Membership is presently restricted to technologists who are certified by the ARRT. Its purposes are to advance the science of radiologic technology, establish and maintain high standards of education and training, to elevate the quality of patient care, and to improve the welfare and socio-economics of radiologic technologists. The home office of the Society is located in Chicago, Illinois.

The one point that I would like to make very briefly is that I would hope that you would not confuse either of these organizations with the ART, which has its home office in Enid, Oklahoma.

So much for the two organizations.

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[1] Chairman, Committee on Legislation, American Society of Radiologic Technologists.

I am delighted for the privilege of speaking to the members of this Conference on the subject of licensure. This subject is not new to the profession of radiologic technology.

My personal knowledge indicates that there were proponents for and opponents to licensure, as far back as 1937. At that time, technologists represented only a very small segment of the medical and allied health professions. Less than 2,000 radiologic technologists were certified by the American Registry of Radiologic Technologists then and hence there appeared to be little need for, nor was there interest in, licensure.

Following World War II there was a tremendous increase in the number of x-ray installations in hospitals, in offices of members of the healing arts, in industrial medicine. Since the AMA approved schools of radiologic technology could not begin to supply the demand for qualified technologists, commercial schools and other on-the-job training programs were utilized and, in some instances, encouraged to fill the gap. Consequently, literally thousands of technicians, poorly trained and unqualified, were employed to administer ionizing radiation to the uninformed public.

National certification has been voluntary since 1922. Since it has not been mandatory that all users and operators of ionizing radiation producing equipment be certified, it soon became evident that some form of licensure might be helpful in correcting this intolerable situation. Some local organizations of technologists became concerned with this problem and persuaded their respective State legislatures to sponsor and introduce licensure acts.

The Commonwealth of Puerto Rico was the first to succeed in this endeavor, in 1963. New York, New Jersey and California followed in rapid succession. Numerous other States have now activated licensure committees to draft model legislation for their respective States.

Radiologic technologists are novices in the political arena when compared to other health professions. They are familiarizing themselves with the many problems associated with licensure and primarily to assure themselves that any legislation introduced and enacted will best serve the health and welfare of the general public and the interest of the profession of radiologic technology.

The American Society of Radiologic Technologists has recognized some of the inherent obstacles in promoting State licensing acts, as follows:

1. The proliferation of standards throughout the United States with the possibility of 50 sets of standards for 50 States. Furthermore, it is highly possible that such State licensing acts would not only fail to provide a uniform standard of protection for the public but could, as well, because of the lack of uniform reciprocity, seriously decrease the

mobility of technologists. We believe this restriction to be detrimental in providing for the essential health needs for the people of this nation.

2. The inability of some States to mount their own programs to provide the desired protection for their citizens.

3. The inability to assure the provision of consistent and uniform protection to the public from the misuse and unnecessary exposure to ionizing radiation.

In order to avoid these objectionable problems, the Board of Directors of the American Society of Radiologic Technologists has recently prepared a position paper on the standards of training and regulations for radiologic technologists, as follows:

> "The value of medical uses of ionizing radiation cannot be overestimated nor should the potential hazards, particularly to unnecessary exposure, be underestimated. These potential hazards, though controversial, are a matter of record. This Society represents the profession that serves as the operator for the radiation-producing equipment and, as such, must be concerned with the control of radiation while not attempting to establish criteria for minimum or maximum exposures.
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> "To attain maximum benefit from the medical use of x-ray apparatus with the least risk to the patient requires the cooperative effort of physician, technologist, and manufacturer. As the primary operator of the apparatus, the technologist bears the responsibility to minimize the exposure to the patient for each examination ordered by the physician within the limitations of the equipment. The technologist must know how to achieve the required diagnostic information with the least exposure to the patient.
>
> "With the practice of medicine becoming evermore sophisticated, the demands placed upon the technologist to render adequate service to the physician and to the patient are increasingly complicated. Moreover, the growth in number of examinations has placed a severe strain on the capacity of existing structures to recruit and to train the new personnel needed. For these reasons, the quality of training of the technologist is a matter of mounting concern.
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> "For the brief life of the use of x rays in the practice of medicine, standards for the training of radiologic technologists have been an evolving and expanding enterprise. Sponsored jointly by the American Society of Radiologic Technologists and the American College of Radiology, the American Registry of

> Radiologic Technologists has operated a voluntary certification program based upon standards of training approved by the Council on Medical Education of the American Medical Association. Approximately 60,000 of the estimated 125,000 operators of medical x-ray equipment have been certified by this program.
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> "The American Society of Radiologic Technologists believes these requirements for certification to be the bare minimum essential to the proper and safe operation of medical x-ray equipment. The American Society of Radiologic Technologists proposes that these standards, at least, form the basis of any governmental control of training by control of certification or by licensure. Furthermore, the American Society of Radiologic Technologists proposes that any governmental control be established at the Federal level to insure uniformity of training and thereby adequate protection to all citizens."

A recent review of the four enacted laws and nine proposed drafts indicates a wide diversity in many areas of the licensing acts.

The major differences relate to the composition of the Board of Examiners; the users of ionizing radiation to be covered by such legislation; the powers of the Board; the agency to which the Board reports; the issuance of various classifications of licenses and; the exemptions to the provisions of the Acts.

It is becoming increasingly obvious that agencies of government, professional associations and other groups are engaged, in some areas, in sponsoring and introducing separate drafts of legislation, many times without consultation with the other concerned organizations. The organization with the greatest political influence is usually successful in having their version of legislation introduced, which may not always be in the best interests of the public or of the professions directly involved. Such situations are often embarrassing and are a disservice to all concerned parties.

I therefore urge that in the drafting of any legislation, consultation with all concerned professions is essential if the resultant legislation is to be meaningful, to serve the best interests of the public and the professions.

The Bureau of Radiological Health has been active for at least two years in preparing model legislation for users of ionizing radiation. This effort has been accomplished in consultation with the American College of Radiology, the American Society of Radiologic Technologists, as well as other agencies of government and professional associations.

There are still several areas of the model legislation in which there is not complete agreement, and I would like to touch on four at this time:

1. The composition of the board of examiners: It is intended that--according to the latest draft--two boards should be constituted; one to include medical users of ionizing radiation, the other to include dental users of ionizing radiation. As presently constituted, it is doubtful that the medical board would be very effective since it includes members of the healing arts, as well as radiologic, radiation therapy and nuclear medicine technologists. Under these circumstances, it is very likely that the text of the legislation and the ensuing regulations would be so diluted that they could essentially be completely meaningless and therefore ineffective.

It is suggested that perhaps it would be more effective to establish separate boards for the various professional disciplines; one for members of the healing arts, another for technological users and a third for members of the dental profession.

Many of the objections, by vested interests, to the composition of the boards of examiners would thus be resolved and strong standards for the various aforementioned disciplines could be implemented.

2. The executive or advisory powers of the board: It is strongly recommended that any and all of the boards established should have executive powers to assure the adoption of appropriate regulations governing all sections of drafted legislation.

3. The issuance of limited licenses: To my knowledge this is the only profession in which there is an attempt to establish levels of competency which are lower than those recommended by the profession. I have not heard of any efforts to provide limited licenses for the practice of medicine, or the practice of dentistry or the practice of nursing, or others.

Members of the American Society of Radiologic Technologists strongly oppose any attempt to reduce the present standards of training for radiologic technologists which is based on the AMA approved 2-year curriculum.

There is some justification for the establishment of a "limited" license for chest radiographers since approximately 40 to 50 percent of the x-ray examinations performed in the United States annually are examinations of the chest. The inclusion of this group of limited practitioners should be predicated, however, on the establishment of an appropriate curriculum and the inclusion of this curriculum in any legislative draft.

4. Two-year minimum curriculum: There is an obvious lack of reference in the draft to the minimum standards of education and training for radiologic technologists as expounded by the American Registry and the American Society of Radiologic Technologists, the American College of Radiology and endorsed by the Council on Medical Education of the American Medical Association.

The American Society of Radiologic Technologists will continue to work with all agencies and organizations and support all efforts which include these basic minimum standards. The Society will strongly resist any attempts to diminish these standards for it is our firm conviction that the diminution of these standards could directly and indirectly endanger the general health and welfare of the citizens of this nation.

Thank you.

MR. FRANKEL: Thank you, Dick, very much. I know that many of the points you raised will be talked about in the next few minutes.

The next speaker that I would like to introduce at this time really needs no introduction. He is a good friend of all of us. So without further ado, I would like to introduce Dr. Simon Kinsman from the California Bureau of Radiological Health who will discuss the California Radiologic Technology Control Act.

CALIFORNIA RADIOLOGIC TECHNOLOGY CONTROL ACT

Simon Kinsman, Ph.D.[1]

Thank you, Bob. I don't need introduction, I just need sympathy at this stage of the game and on this subject. I notice that the session this morning was operating under the hippie law, hippie being an inverse square. That is, the time allocated to the subject was inversely proportional to its importance in the public health aspects of radiation.

The purpose of the legislation which California adopted known as the Radiological Technology Act was advancement of the public health by protecting the people of that State from excessive and improper exposure to ionizing radiation. The legislation furnishes the foundation for a two-pronged approach. Persons using x rays are required to meet certain standards. In addition, regulations may be adopted which govern the manner in which x rays are used.

The State Board of Public Health is the responsible State agency. Actual regulation is accomplished, as a practical matter, by the Radiologic Technology Certification Committee.

The Board consists of nine members, and this is different from any other existing legislation or any recommended legislation. I won't say that this is good. This came about by a good pressure play by certain vested interest groups.

The Board consists of nine members. Five must be physicians and surgeons. Three of the five must be Board radiologists, and one of the radiologists must be representative of the hospital practice of radiology. Two of the members are to be radiologic technologists, one from hospital practice. The remaining two members are a radiological physicist and one licentiate of the healing arts who is not a physician or surgeon. That left it up to the podiatrists or chiropractors. And as the Board is constituted, the chiropractor is now a member rather than a podiatrist because they have a lot more x-ray machines to operate; they also have a lot more political pressure on their side.

This legislation gives statutory recognition to a new category of paramedical personnel. It does not provide for "licensing" as such, but provides for "certification" of radiologic technologists. The reason for the so-called certification versus licensing was the physicians said, "We are already licensed to practice, and we don't see any need of getting a secondary license to do this work."

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[1] Chief, Bureau of Radiological Health, California State Department of Public Health.

Also, when a physician is licensed and wants to be a radiologist, then he gets certified by a Board of Radiology so the certification seemed a little more logical term than licensing. The technologists would have preferred to have the word "license" in there.

A radiologic technologist is a technician using x ray without limitation as to procedures or areas of application. Separate certificates are provided for diagnostic and for therapeutic radiologic technology.

In addition, the legislation provides for granting "limited permits"--like Mr. Olden said, he wasn't sure he would recommend this--to persons to conduct radiologic technology limited to the performance of certain procedures or the application of x ray to specific areas of the human body. In this regard, it should be noted that the holder of the limited permit is not "certified."

From the standpoint of the medical provision, subparagraphs (e) and (f) are extremely important. They provide that the Board of Public Health shall:

> "(e) Provide, upon recommendation of the committee, for certification of licentiates of the healing arts to supervise the operation of x-ray machines or to operate x-ray machines, or both"--that is, the licentiate has to have an operator's certification or a supervisor's certification or both. And the committee will "prescribe minimum standards of training and experience for such licentiates of the healing arts"--and, of course, to the technologists--"and prescribe procedures for examining applicants for certification. Such certification may limit the use of x rays to certain x-ray procedures and the application of x rays to specific areas of the human body.
>
> "(f) Upon recommendation of the committee, the Board will exempt from certification requirements licentiates of the healing arts who have successfully completed formal courses in schools certified by the Board and who have successfully passed a roentgenology technology and radiation protection examination approved by the Board and administered by the Board which issued his license."

That is, it would have to be approved by the Board of Health. But it would be administered by the Board which issued their license.

Accordingly, even physicians must be certified to use x-ray machines, unless they are exempted by subsection so and so, or unless they come within the scope of another section, which "grandfathers" licentiates of the healing arts who operated or supervised the operation of a properly registered source of ionizing radiation prior to July 1, 1971.

The reason we put that in there, and you may be interested to know this, is one phrase the Health Department really needed. Fifteen percent or so of our licentiates have not registered. The figures will be a little more accurate a little later because there is a grant given to determine the number of unregistered users. It is about 15 percent or so, and we figure this might identify them in registering with us by saying that unless they were working on a properly registered machine by July 1, 1971, they could not be "grandfathered" in.

Obviously, physicians wishing to take advantage of this provision must insure that their equipment has been properly registered.

The new law is not yet effective. There are two different effective dates, depending on whether or not the individual desiring to use x ray is a licentiate of the healing arts. That is, the technicians have to be certified six months ahead of the physicians.

A section provides that "it shall be unlawful for any person to administer or use diagnostic or therapeutic x ray on human beings in this State after July 1, 1971, unless such person has been certified or granted a permit.

A section provides that it shall be unlawful for any licentiate of the healing arts to administer or use a diagnostic or therapeutic x ray on human beings in this State after January 1, 1972, unless such person is certified. Therefore, technicians must be certified or granted a permit by July 1, 1971. There is a 6-month interval. Physicians and other licentiates of the healing arts must be certified by January 1, 1972.

As has been noted, licentiates who operated or supervised the operation of a source of ionizing radiation prior to July 1, 1971, are entitled to be granted a certificate to continue such operation or supervision without examination or qualification.

Similarly, a section provides that "a licentiate of the healing arts who is certified by an examining board in radiology recognized by the Department shall be granted a certificate to supervise the operation of x-ray machines without restrictions." The way the law is written, there is a considerable redundancy. But you have to put it in legal parlance in order that the physicians will understand it.

Any physicians who do not operate or supervise the operation of x-ray equipment prior to July 1 or who are not board certified in radiology, will have to be qualified by examination prior to January 1, 1972, pursuant to such and such subsections.

Standards of training and experience and procedures for examination have not yet been developed by the Committee or adopted by the Board. We are in the process now and the process is pretty slow because there is not a great deal of agreement between the physicians and technologists.

It should also be noted that a section provides that the Department shall grant special permits to persons excepting them from the scope of this legislation if it is demonstrated that persons in a particular geographic locality would be denied adequate medical care because of unavailability of certified or certifiable radiologic technologists.

Violation of the new legislation is a misdemeanor, and the Department of Public Health may also discipline certificate or permit holders.

This is the part Florida wants to hear now. The application fee for any certificate or permit has not been fixed, but may not exceed $25.00. This is what the APHA charges for their examination if you use APHA exams. The annual renewal fee may not exceed $10.00.

No attempt is made to discuss those provisions of the Act which deal with schools for radiologic technologists, standards for their qualification, and similar provisions which deal particularly with radiologic technologists.

Thank you.

MR. FRANKEL: Thank you, Si, very much. We certainly do appreciate your most candid comments and know that they will be of great benefit to us in our discussions. And we also want to wish you and your program all the luck in the world in California.

DR. KINSMAN: We will need it.

MR. FRANKEL: Now, with your permission, I would like to slightly modify the program and have as the next speaker Mr. Bobby L. Dillard from the Office of Regional Operations, Bureau of Radiological Health, who will speak on a topic that has been discussed already twice by both the previous speakers--model legislation. This draft, "Model Legislation for Users of Ionizing Radiation in the Healing Arts" has been approved at the Bureau level.

Mr. Dillard.

MODEL LEGISLATION

Bobby L. Dillard[1]

Experience over the years has shown that the complete inspection and correction of inadequacies in x-ray equipment or installations as a result of visits by inspection people does not guarantee the proper use of medical x-ray equipment. Examples of poor technique reported are:

- repeated exposures of the same patient to obtain a suitable radiograph;
- larger than necessary beam sizes;
- technicians repeatedly holding patients or films;
- high film badge readings being misunderstood or ignored; and,
- technicians with limited training in the concepts or purposes of radiation protection.

Too often, individuals using x ray for diagnosis have taken the position that since they cannot see clinical evidence of radiation damage, either to themselves or their patients, radiation protection is not really necessary.

With the population of the United States being exposed more frequently to medical x rays and radioisotopes for diagnosis or therapy, the avoidance of needless radiation exposure becomes a major health concern. Hence, there is a need to eliminate as far as possible, the untrained and unskilled people administering x rays or radioisotopes to human beings.

Traditionally, the individual States have assumed the responsibility for protecting their citizens from all health hazards and there is no logical reason why the control of radiation should not follow the same historical development.

The protection of the public from unwarranted radiation exposure is properly the responsibility of the State Radiation Control Program. Experience in the fields of safety engineering, industrial hygiene, health physics and public health has shown that the "safety man," the one responsible for the health and welfare of the group, should not necessarily be a part of the group. Whenever a member of a group also functions as a safety man, it frequently happens that the safety considerations are made subordinate to the other primary objectives of the group. "Getting the job done" somehow becomes more important than getting it done safely.

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[1] Chief, Regulatory Relations Section, Office of Regional Operations, Bureau of Radiological Health, Public Health Service.

It cannot be denied that many of our radiologists are well informed about the biological effects of radiation and do not expose their patients unnecessarily. Too often, however, their supervision of the technician who actually operates the x-ray machine is minimal. What is of further concern are the thousands of other practitioners who have no idea of the potential hazard associated with the use of radiation.

What can we do about these people?

We can adopt a course of action that will drive to the heart of the problem; namely, education of the authorized users of radiation apparatus.

The United States Public Health Service has several public advisory committees consisting of outstanding individuals to advise it on difficult and sometimes controversial subjects. The National Advisory Committee on Radiation in 1966 made recommendations to the Surgeon General on technical manpower in the field of radiological science. Included in this report was the following statement:

> "It is hoped that, in the years ahead, the lot of the chronically underpaid technologists may be improved. Without this change, it will become increasingly difficult to increase the effectiveness with which radiological services are delivered to the public. The establishment of minimum legal standards of education, training, and experience for such technologists appears to be necessary to bring this about."

A Report of the Medical X-ray Advisory Committee on Public Health Considerations in Medical Diagnostic Radiology was submitted to the Surgeon General in October 1967. In view of the need for more physicians and auxiliary personnel appropriately qualified in the use of x rays, the Committee was specifically requested to suggest means by which this need could be met. It responded as follows:

> "There is increasing interest in the means of assuring that all medical x-ray equipment operators meet agreed standards of knowledge and competence. The voluntary procedures of certification by the American Registry of Radiologic Technologists set a generally high level of such assurance, but are not universal. Certain States have already introduced programs of licensure, based on examination as well as training and experience.
>
> "The Committee believes, however, that the prime consideration should be the total public health interest and that the stage has been reached when mandatory requirements of examination, training, and experience are appropriate. The committee holds no brief for licensing per se, but recognizes that in many instances it may be the best mechanism for assuring the fulfillment of minimum

> requirements. It can be accomplished gradually, however, with a transition period to avoid the disruption of vital radiological services if such programs are put into effect. Uniformity in standards for such actions would be highly desirable.
>
> "Implicit in a mandatory training requirement is the necessity for accreditation of the schools of x-ray technology to insure that the standards of quality and quantity of training are adequate and maintained."

Approximately 90 percent of the registered technologists work under the supervision of radiologists, together forming a team that operates approximately 50,000 of the x-ray machines used in the practice of medicine in the United States. Licensing laws for this group alone would do little to control unnecessary radiation exposure and would not satisfy the purpose of such legislation. It could be that the law would require all professional personnel to employ only a licensed technologist. At the present time there are approximately 175,000 x-ray machines (including dental) under the supervision of non-radiologist practitioners. Even if there were sufficient numbers of qualified technologists to operate these machines, the profession may not be able to economically support such a person. This situation is further compounded by the fact that most non-radiologist practitioners perform only a limited type of examination and a qualified technologist would not be fully utilized in such installations.

From the information cited, it would appear that licensure may be an approach to this problem but must be broader than mandatory requirements on only one classification of x-ray machine operators.

History

In October 1969, a draft of "Model Legislation for Radiologic Technology" was prepared and sent to the Bureau of Radiological Health Regional Representatives, Directors of all State Radiation Control Programs, members of the X-ray Image Production and Related Facilities Advisory Committee, and other interested individuals asking for their review and comments.

A revised edition of the "model" was prepared in November 1969 and sent, for review and comments indicative of the position of their organizations, to the American Chiropractic Association, American Dental Association, American Medical Association, American Podiatry Association, American Society of Radiologic Technologists, and the American College of Radiology.

On February 5-6, 1970, the X-ray Image Production and Related Facilities Advisory Committee again met and approved the concept of the California Radiologic Technology Law.

These reviews prompted another draft in February 1970 entitled "Model Legislation for Users of Ionizing Radiation in the Healing Arts."

On March 4, 1970, a meeting was held in San Francisco, California, with

- William C. Stronach, representing the American College of Radiology;
- Richard A. Olden, representing the American Society of Radiologic Technologists;
- Dr. Simon Kinsman, representing the Conference of Radiation Control Program Directors;
- Dr. Reynold F. Brown, representing the X-ray Image Production and Related Facilities Advisory Committee;
- Dr. Clifford E. Nelson, Radiological Health Representative, Region IX; and
- Dr. James W. Miller, Director, Office of Regional Operations, Bureau of Radiological Health.

General agreement of the concepts of the "model" was apparent following minor changes in the February draft.

Major Changes

Since the October 29 draft, there have been some major changes in the "model":

1. The title has been changed from "Model Legislation for Radiologic Technology" to "Model Legislation for Users of Ionizing Radiation in the Healing Arts."

2. In the first drafts, the definitions were arranged in alphabetical order. There seemed to be some confusion and discontinuity when trying to follow the definitions. These have been rearranged and now I believe the problem has been solved.

3. It became obvious there was a need to define and clarify the various types of certificates and permits which are to be issued under the model. Three new definitions were added:

- General Certificates, which means General Technologic Certificates or Licensed Practitioners General Certificates;
- Licensed Practitioner General Certificate, which means a certificate issued in radiologic technology to a practitioner who supervises and/or applies ionizing radiation to any part of the human body;

- Licensed Practitioner Limited Certificate, which means a certificate issued in radiologic technology to a practitioner who supervises and/or applies ionizing radiation to specific areas of the human body.

These titles were used throughout the model.

4. There was much discussion and many comments on the earlier drafts concerning the makeup of the Boards. The makeup now for the Medical Board is:

- 5 physicians, at least 3 of whom shall be radiologists;

- 3 radiologic technologists;

- 1 licensed practitioner of the healing arts other than medicine or dentistry;

- 1 other person who shall be technically qualified or knowledgeable by training and experience in one or more fields of science or engineering applicable to radiation safety in the healing arts; and,

- the agency director or his designee, who shall serve as chairman.

The makeup now for the Dental Board is:

- 3 dentists;

- 1 radiologist;

- 1 dental hygienist;

- 1 other person who shall be technically qualified or knowledgeable by training and experience in one or more fields of science or engineering applicable to radiation safety in the healing arts; and,

- the agency director or his designee, who shall serve as chairman.

5. The paragraph concerning compensation to board members has been rearranged and reworded so as now to allow for compensation to board members.

6. The powers of the Boards have been changed from advisory to executive, and much clarification was made throughout the model detailing the duties of the Boards and the responsible agency. There is a "check and balance" system built into the model.

7. The power to grant special permits to persons in rural areas where patients would be denied adequate medical care because of the unavailability of certified licensed practitioners or persons holding general certificates has been added.

8. Also, the power to issue a temporary permit to an applicant who has complied with the provisions of the act and is awaiting examination has been added.

9. Minimum qualifications required of an applicant to receive a limited permit have been added. Namely, that he will be required to pass an examination similar to that required for a general technologic certificate, but less stringent. It should include all questions given for a general technologic certificate that pertain to the specific procedures in question.

Now to requote from the Report of the Medical X-ray Advisory Committee on Public Health Considerations in Medical Diagnostic Radiology:

> "The prime consideration should be the total public health interest and that the stage has been reached when mandatory requirements of examination, training, and experience are appropriate."

MR. FRANKEL: Thank you, Bobby. Is it my understanding that copies of this draft model will go out to all the States sometime next week?

MR. DILLARD: Everyone here will receive a copy of the model.

MR. FRANKEL: The comment is "When?"

MR. DILLARD: It is going to take some time to xerox it. The model is 33 pages long. So hopefully within a week or two. I will start on it immediately Monday.

MR. FRANKEL: Thank you, Bobby.

The last speaker on the formal presentation will speak on the topic of reciprocity.

On every radiologic technologist licensing bill I have seen up to now, there has been a "grandfather clause." And, indeed, we also in my opinion have a "grandfather" of x-ray technology in terms of licensing on the mainland, Mr. Howard Goldman.

Mr. Howard Goldman, since 1964, has been the Director of the Bureau of X-ray Technology of New York State and was also Chief of the X-ray Services Section of the New York State Bureau of Radiological Health from 1960 to 1964. In addition, he was elected Chairman of the National Association of Boards of Radiologic Technology at a meeting held last February in New York City.

Mr. Goldman, the podium is yours to speak about reciprocity. I hope you also tell us the purposes and functions of the National Association of Boards of Radiologic Technology.

RECIPROCITY

Howard L. Goldman, LXT[1]

In a special aside just recently to Si Kinsman, he mentioned that with the advent of California's licensure bill for x-ray technologists and New Jersey's and New York's, we now cover about 20 to 25 percent of the total population of the country under this type of law.

And, of course, the handwriting is on the wall. Licensure will come to x-ray technicians. It has been on the wall now for a good number of years--six or seven at least. It has been a latent image. Some people just haven't seen it as yet. I started losing track, but about a year and a half ago, there were about 17 other States in various stages of preparing a bill or trying to move it through the legislative process. So we are going to have many more States with licensure. The question is, what kind?

A problem we also have to watch for is: As each additional State obtains legislation for the licensing or certification of x-ray technicians, there is a danger of a proliferation of standards. Dick Olden mentioned this. But what is more important is the possibility that some States will accept substandard provisions in their laws.

It is obvious that planning is necessary to assure uniformly high standards so that technicians who meet these standards can move freely from State to State without having to again establish their qualifications with each move.

The first step to accomplish this has been taken with the formation of the National Association of Boards of Radiologic Technology, which Bob Frankel mentioned. At a meeting held in New York City on February 10, 1970, the National Association was founded, and tentative by-laws were developed.

Those participating were the three States that presently have licensing or certification--namely, California, New Jersey and New York. Also, there were representatives of the U. S. Public Health Service's Bureau of Radiological Health, representatives of the ARRT and a representative of the ASRT.

The by-laws of the National Association assure reciprocity among participating States under high standards which are generally recognized as necessary for the competent practice of x-ray technology. Each participating State and others who later enter the National Association of Boards will be required to:

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[1] Director, Bureau of X-ray Technology, New York State Department of Health.

1. License or certify technicians under standards of two years or more of schooling with at least 400 hours of technical classroom instruction and with adequate clinical experience at general hospitals.

2. Each participating State will be required to maintain adequate surveillance of schools in their State which includes regular site visits.

3. Each participating State will be required to license or certify with written examinations of appropriate difficulty for graduates of 2-year approved schools, with the examination of at least 150 multiple choice questions covering every subject of instruction.

Now, providing these standards are met, participating States will recognize the graduates of one another's approved schools and the passing of one another's examinations.

They will also adopt uniform standards for such things as acceptance of armed services training and will not impose State residency requirements.

They shall freely exchange information on applicants licensed or certified in one State who apply for licensure or certification in another State.

They shall inform applicants of opportunities for reciprocity in State application materials that are being distributed.

The standards for reciprocity only apply to persons licensed under ongoing provisions of each law--basically, the 2-year school and the "tough" examination, as we call it. They do not apply to "grandfathers" licensed or certified by any State under more lenient standards at the inception of the law.

Reciprocity does not apply to persons issued limited or special licenses, permits, and so forth, under standards below those accepted by the National Association of Boards. Now, this is important. It is important since the model legislation being proposed by the U. S. Public Health Service advocates limited licenses.

A long-range goal of the National Association of Boards is the establishment of one nationwide examination, hopefully in cooperation with the ARRT. For that reason, the ARRT was invited to the February meeting. I might add that its board is now considering this matter.

Also desirable is establishment of a nationwide clearinghouse to review the qualifications of applicants licensed in any participating States who wish to move to other participating States.

Drawing from what I have said, it becomes obvious that an extremely important factor in establishing adequate reciprocity among States is that each State pass a law which is basically sound and in conformity with the high standards already established on a voluntary basis by the American Registry of Radiologic Technologists.

Where laws are passed which contain weak provisions for excessive exemptions, special limited licenses, geographic exceptions, and so forth, reciprocity, if at all, can only be very limited.

But aside from its hindering the goal of reciprocity, loophole laws, as I call them, fail to attain the basic purpose of licensure or certification of x-ray technicians, which is basically to protect the public from unnecessary or excessive exposure to radiation.

And, in my very strong opinion, the model law which is being put forth by the U. S. Public Health Service is an example of such loophole legislation.

The only logical justification for the need for any law to license or certify x-ray technicians is the supposition that there exists some poor practices that the law is intended to correct. If this is not the case, you don't need a law. The basic poor practices in the field of x-ray technology are of two kinds:

1. Persons who are allowed to become x-ray technicians without adequate training and establishment of qualifications by examination; and

2. Persons who are allowed to operate x-ray equipment around the periphery of the profession, such as medical assistants, nurses, medical secretaries, and so forth, who have no reasonable pretension to competence in the field and generally don't even consider themselves to be x-ray technicians.

The model law, by setting up the two categories of general certificate and limited permit will probably fail to correct either of the two important practices described previously. It certainly will completely fail to correct, and will probably even exacerbate, the second poor practice of permitting the completely unqualified assistant to take x rays.

Instead of discouraging this poor practice, the model law will give it a new respectability. Its basic assumption is that the only matter concerned in a radiograph is its clinical adequacy and that no concern need be given the amount of radiation which the patient receives either through poor technique or unnecessary retakes.

The model law also makes another basic mistake in that it does not clearly differentiate between the proper role of the physician and the technician. A law for technicians should deal with the technician function which is in the areas of techniques and radiation safety. If standards are to be established for physicians, it should not be in this area, but in their proper areas of judgment when to order or not to order an x ray and competence in properly interpreting the x rays.

The model law asks the question: Can the physician take an x ray properly? When it really should be concerned with the questions: Was the x ray necessary? And is proper use being made of the x ray?

However, most fundamental, the model law is completely tailored to uncritically meet the needs of the status quo in medical practice. By the use of loose, ambiguous provisions, it gives legal sanction for the continuation of the existing poor practice by providing an unqualified x-ray machine operator for every physician, whether or not qualified, who has an x-ray machine.

Thank you for listening to me.

MR. FRANKEL: Thank you, Mr. Goldman.

It becomes obvious at once there is a difference of opinion among the panelists.

At this time, let's open up the floor to any questions that anyone may have to any member of the panel, or, indeed, among themselves. What we will ask, however, is that you do identify yourselves by name and by program first.

Are there any questions, please?

MR. CROSBY: Crosby, South Carolina.

Anyone of the panelists: What is this going to do to the cost of x ray? I think about the old comparison, try to get a registered nurse by your bedside. I wonder how much of this licensure is anticipated to affect the cost of x-ray diagnosis.

MR. FRANKEL: Gentlemen, who would like to respond to that?

Mr. Goldman, you have had more experience on this in the State of New York, so possibly you could best respond to it.

MR. GOLDMAN: I don't know if I could really answer that question specifically. I don't know the exact cost of an x ray in New York State today. But we have licensure now since 1965, and I don't think it is any more than in any other State.

Salaries for technicians have gone up, but I think there was enough fat in the profit of an x ray that it was easily absorbed.

MR. FRANKEL: Dr. Kinsman.

DR. KINSMAN: I will try to answer it realistically. You want to know what it will do to the cost to the patient. It will probably double it.

The reason I say that is when we tried to get our law requiring registration of the equipment, of the x-ray generator, this was established in the law that didn't pass as $15. And the radiologists were ready to let that whole law go down the drain because this was too expensive.

On the basis of the radiographs they take, this would have been less than a mill per picture or radiograph per year. But the prices that resulted from that were considerably more than a mill. And it wasn't even in less than a dollar range. I think the licensing would add something similar to this increased cost.

That is just a guess, not scientific.

MR. FRANKEL: Thank you, sir.

Before we have any more questions, there is one point I would like to make sure we understand clearly. Mr. Goldman mentioned a USPHS model licensing guide. Actually, it is a BRH draft document at this stage of the game.

Dr. Parker.

DR. PARKER: Roy Parker from Louisiana.

I would like to make two comments to Mr. Olden. I think there is some precedent, particularly in the medical profession and more specifically in the use of radiation for limited type of licensure or permit. That is, within the use of nuclear medicine, a person or a physician can only be licensed when he has received a certain level of competency. And many times, this is by specific groups or procedures or by levels of experience. So there is a precedent there.

Also, if we are going to go on the basis of tradition, I would like to point out that I know of no case where there is licensure based on a health and safety field in the medical profession on the Federal level. The health and safety function has always been traditionally a State level.

So, I think within this framework or argument, you are contradicting yourself here in two cases.

MR. OLDEN: Well, not really. At least I don't think so.

First of all, I think there is ample evidence that the AEC has established Federal regulations for the use of ionizing radiation. So, in effect, we already have Federal regulations controlling radioisotopes.

Secondly, the majority of the users of radioisotopes through regulation at the Federal level, are normally first certified as physicians. And it is only after they have earned that initial certification as physicians that they can apply for the additional licensing for the use of radioactive isotopes.

So there is precedent for Federal regulations. Furthermore, I am not suggesting this be a Federal licensing bill--don't misunderstand me--because I do not agree with this concept at all. But I think that somewhere in Federal legislation, there should be included Federal minimum standards.

You can all remember Section 360(g) of Public Law 90-602. The Society would not have objected to this portion of the bill had there been written into that 360(g) section the provision of the two years of minimum training.

MR. FRANKEL: Thank you.

Question, sir?

DR. PARROTT: Marshall Parrott, Oregon.

You missed one small group of people that have been taking x rays. And that is the housewife orthopedist in Louisiana. I am much, much in favor of adding nuclear medicine to the State program. Radiologists are qualified, possibly, but nuclear medicine is absolutely essential.

MR. FRANKEL: Questions, please?

MR. BOND: Aaron Bond, New Mexico.

I have a couple of questions I would like to ask and then an editorial comment.

I wonder as an individual working in a regulatory agency if you change this advisory board for licensing of your radiological technologists or whatever you want to call them to that of an administrative board if we might not be developing a two-headed monster that is almost impossible to administer.

I wondered if any of you would care to comment on this, please.

MR. DILLARD: I don't know if I can. We certainly haven't had any experience on this yet. And I really think Dr. Kinsman is the man to talk on this.

DR. KINSMAN: Go ahead, Goldman.

MR. GOLDMAN: I think Si Kinsman has some experience with it already--a sad type of experience, I believe, Si.

From our point of view, having an administrative or an executive board is very dangerous. It is a two-headed monster.

First of all, it creates a power within a power. No commissioner of an agency in his right mind wants a board of this type. He is running other programs--he is running a program in rad health, for instance--and he is running a program in licensure.

Now, if he has an independent board that can overrule him, they might overrule him on some items that might hurt his other program. He couldn't allow this. A commissioner is responsible for his whole department. And if I was a commissioner, I would not sponsor any legislation that had an executive or an administrative board put within my own agency.

It is as simple as that.

DR. KINSMAN: I will have to agree with what has been said. The only way I see around it since we are stuck with it is that you get an effective chairman--and by effective, one who can guide the board so you get what you want out of the board or committee and avoid these problems--otherwise, it is a two-headed monster.

MR. GOLDMAN: Si, can I say one more thing on that?

Another thing that must be realized is that on this administrative or executive board, these people are generally drawn from different agencies, radiologists, technicians working in hospitals, and so on and so forth. These people even if you pay them, can only meet at best once every two or three months. Our board meets about twice every year now. You can't expect them to do all the work. You can't wait between board meetings for important policy decisions to be made. This has to be done by the agency administering the law. And in that case, it always gets too bogged down.

MR. FRANKEL: Thank you, Howard.

Mr. Bond, you had another?

MR. BOND: Yes. Thank you very much.

These are the kind of problems we foresee with it. And I think this is probably the most effective way to discourage States from adopting regulations for the licensure of technologists.

And one of the other points, I think, that is of concern is the possibility for developing a constituent agency perhaps which would also have responsibilities for certain aspects of radiological health. And I am not sure in our particular State it would create very large problems. If it were an advisory committee, I think it would work. If it were an administrative committee, then I would suggest that it not be housed within the particular agency which has control, but go back to that of a professional licensing board with a representation from the State regulatory authority.

Thank you, sir.

MR. WILL: Bob Will, Kansas.

Are you administering this program as the Bureau of Radiological Health in California or as a member of a committee made up of people...

DR. KINSMAN: We are administering it by our Bureau of Radiological Health. And all the work Howard was talking about will be done there. The guidelines will be set down, policies from the advisory board at their meeting, and all of the work will be done by us or contracted for by us, such as examinations, practical examinations, and so forth.

MR. WILL: How about New Jersey or New York?

MR. GOLDMAN: In New York, the work is done by a bureau set up specifically to administer this law. It is called the Bureau of X-ray Technology, and it is just another bureau in the department.

MR. FRANKEL: And in terms of New Jersey, we have Mr. Bill Aaroe from the State of New Jersey who could respond well to that question.

MR. AAROE: I don't know how well I can respond.

In New Jersey, the board is executive as contrasted to other views expressed here this morning. It has worked pretty well as far as I am concerned. The board itself has made its own examinations as contrasted with other views expressed here this morning.

That's all I have to say.

MR. FRANKEL: Thank you.

MR. HARRIS: Well, I would like to find out where the public is represented in any of these discussions on establishment of some of these programs. As you know, I am the health physicist member of the New York State Board of X-ray Technician Examiners. And as I sit at the panel, I needle Howard because I feel as the health physicist member and the public health man, I am the closest to being the "representative" of the public. And I am a little concerned that in a board with 10 people, it may be a little difficult.

Maybe Si can comment on how well this is going to operate in California with five physicians, three radiologists and two radiological technologists.

The other thing in California that I am concerned about, in the number of positions on the board, is literally not exempting, but establishing such low standards that any physician could qualify under almost any conceivable circumstances in the future. Therefore, the purpose of the law would be circumvented.

DR. KINSMAN: I think Saul is right, the way the board is set up, there is power vested in a particular special interest group. It was so written in the law.

It didn't even say that. It says that the board will consist of 10 members, one who will be from the Department of Public Health and be the director's designee, but he will be the chairman and have no vote.

Then there are nine members which vote. And they also state that five votes are all that is necessary to carry anything. And there are five physicians on the board.

MR. FRANKEL: Dr. Miller.

DR. MILLER: But the agency doesn't have to accept the recommendations of the board.

DR. KINSMAN: The agency does not have to accept the recommendations of the board. This is a so-called checks and balances. The Department does not or the Board of Public Health does not have to accept anything that this committee originates. The Board of Health can't originate anything themselves. So they can't pass anything without concurrence of the committee.

What originates in the committee, then, the board has a choice of saying yes or no.

You wanted to know whether the public was represented in this committee. I will just say one word with regard to that and a little more on Mr. Will's question.

By administering it the way we think we are doing or intend to do, we think we are taking the public's interest into account. In so doing, we have put this action or this group that will be doing the certification work in a unit or section of the Bureau. We expect to have a staff of around seven when we are licensing or certifying technologists. As soon as we bring the physicians in, we will add three more people. So there will be a staff of 10 to do this job.

We placed this activity in a section--and I want to say this so you won't think I am primarily prejudiced on electronic product radiation--we established it in a section called Electronic Product Radiation Control. In that section we have the machine registration and inspection and the personnel certification. The radiation protection specialists, as we call them in our group, have had to be qualified as an x-ray technologist or radiological technologist and have had two years of supervisory work with x-ray technologists. So when they have an on-the-site inspection of x-ray equipment, they can evaluate the persons holding a certificate or a permit.

Part of this is somewhat of a consultation and educational program with the technologist on the job so we have an opportunity to actually see and talk with the individual when we are actually certifying and, as I say, inspecting equipment, too. So we think there is some fair public representation or there is somebody looking out for the public in this program, even if it is our Bureau of Radiological Health.

MR. FRANKEL: Thank you, Dr. Kinsman.

Further questions?

MR. BRITTON: Ted Britton from Georgia.

I would like to ask how the Federal installation is going to be influenced by State licensing programs since most of them are exempt from any State laws.

MR. FRANKEL: A couple of ways to respond to that: I know in New York State, for example, there is the PHS hospital at Staten Island. Maybe Mr. Goldman would like to talk about that first of all and after that Mr. Dillard.

MR. GOLDMAN: I don't know if our way is really the best, but this is how we handle it. First of all, you are right, all Federal installations, all technicians working in Federal installations, are exempt in New York State. There is a school for x-ray technology in the U. S. Public Health Service Hospital on Staten Island. We found many deficiencies in this school. But since they were exempt, we told them that they could still operate but none of their students would be able to qualify for examination in New York State. However, since they wanted approval, they did upgrade their school. It took a period of two years, but they upgraded the school so that now it is a very good school. It is one of the better ones, and they have gotten approval. They have conformed to all the provisions of the law of New York State so that they could get approval, although they didn't have to. They wanted it.

I don't know if this will happen in all cases. I rather doubt if it will. But this is the instance in New York State.

MR. FRANKEL: Thank you, Howard.

Mr. Dillard.

MR. DILLARD: I think the answer to that question probably showed up Sunday in Congressman Rogers' speech. Right now, there is nothing to be done about it. But at least there is some hope.

MR. FRANKEL: Thank you.

Further questions?

MR. LLOYD: Lloyd, Montana.

We have discussed this morning the licensing or certification of x-ray technicians in order to establish a level of competency for practice. Is there any provision made in the model legislation or in any of the existing State programs to insure a level of competency such as retraining, reexamination or something along these lines?

MR. FRANKEL: The question was is there any provision made in either the BRH model or existing State laws to insure the competency, the retraining and training of individuals so licensed?

MR. DILLARD: No.

MR. FRANKEL: Dr. Kinsman?

DR. KINSMAN: There isn't a provision as such at this time but there is legislation in the legislature now in California which would do this. We don't know whether it will pass or not.

The bill says that in any of our licensing work or certification that there would be a provision or would be an opportunity or we would have to set up an arrangement that the certified people could establish the fact that they have been keeping current, that they have received some education during certain periods of time. We are thinking about once every four years on their application that they give us evidence that they have taken so many courses, or they have received so many credits, attended State technical society meetings or something of this order.

I hope it will go through. The first hearing in the first committee that was heard on, who objected--the California Medical Association on behalf of all the rest of the people. It said, "We are ready, we can do this, and this will be all right. We are doing it anyway. But we know all the rest of the people being licensed are not, and therefore, we object to it."

MR. FRANKEL: Mr. Goldman.

MR. GOLDMAN: There is no provision in our law as such. However, we do hold refresher courses. But, as yet, there is no provision for reexamination after additional education.

MR. FRANKEL: Thank you.

MR. HALPERIN: Halperin, Chicago.

Two comments. It is interesting that the AEC in 10 CFR Part 34 made the original commitment of retraining of industrial radiographers. This is a requirement that each Agreement State adopt in its regulations. It is very interesting to note we are much more worried about the competency of this person to use his equipment competently to radiograph welds than we are for other persons to use radiation machines on human beings.

Second, this retraining requirement is not something unique to radiographers or x-ray technologists. The State of Kansas has had a retraining requirement to renew its pharmacy licenses for, I think, three years now. A certain amount of training is required each year and a great deal of it is done by the State through the University of Kansas Extension Service. I suggest that this is something we may want to look into nationally for x-ray technology--running an extension service program for recertification.

MR. FRANKEL: Thank you, Jerry.

Any further questions or comments?

Mr. Marshall Little, BRH, Rockville.

MR. LITTLE: It seems to me that Howard Goldman's National Association of Examiners seems to get at the problems of State licensure that Mr. Olden referred to and possibly could resolve some of those problems. I just wanted to know what Mr. Olden thought about it.

MR. FRANKEL: Mr. Olden?

MR. OLDEN: I believe this National Association of Board of Radiologic Technology is a good idea. But again it is a voluntary organization. This is not a mandate for any of the States to have to join this association.

Do you follow me?

So this again is voluntary, not mandatory. If voluntarily all 50 States would agree to join such an association, it would probably be a good idea. But perhaps even in Federal legislation, something of this nature could be incorporated.

MR. FRANKEL: Further comments?

If not---Mr. Arve Dahl, BRH, Rockville.

MR. DAHL: I think it would be a mistake not to let there be a little thought about what about the future and our own obligations in this field. This is a very dynamic action that is occurring today, and I don't think there is any one road that is the correct one that we can chart at this time.

I think that there has been an awful lot of effort and interest on the part of the technologists. And truly, if you look at the program in general, it has been a bootstrap lifting effort by the technologists themselves. And they must be given tremendous credit.

I think if one looks at the effort and relationships, you will find that there will not be any one approach that will satisfy all States. And if you had a Federal law that would serve the country as a whole, the variations between the States and the programs would result in variations in the various States.

So that what we come down to is a need as a group of workers, Federal and State and local, working together to understand the problems in depth and work with your colleagues and work with your technologists in your States. We in the Bureau have been trying to work with the ASRT and the ARRT and all the other technologists groups for a number of years now. And I think this effort will continue.

And one of the things we did to try to get some consensus in the country from the various technologists groups and the medical groups was to sponsor the 1966 Conference on X-ray Technician Training. It did bring together everybody that had been a force in the country. Dick was a major force in helping it operate. Howard Goldman was on the program at the time. I think if you talk to these gentlemen, you will get ideas of how to work in your own States.

One other thing: What can we as groups do? Certainly, just as happened at this meeting, you can bring these people into your own conferences in your own States when you talk about radiation control. Some of the things we have in mind doing which have not been officially announced, but will soon, for instance, we are planning another conference relative to X-ray technician training. But it is in a very select area. It is on the problem of junior college x-ray technician training or x-ray technologists training.

There is a real problem of bringing the medical and educational community together because they are both motivated with constraints on each side. And what we hope will come out of this conference which is scheduled in the fall, Labor Day week in September, is somewhat of a primer or a discussion of the problems that have to be dealt with in organizing joint programs.

I think we have the essentials that have been set up for college affiliated programs by the Council of Medical Education. These largely evolved as the result of the work of the American College of Radiology and American Society of Radiologic Technologists and the American Registry of Radiologic Technologists.

Now, a couple of points: You have to recognize as far as we are concerned, the AMA-sponsored or affiliated groups do not represent all technologists. There are other medical groups in this country. We as public servants have to recognize them all. So you have to look beyond this one group.

Dick and I talked about this, and on the steering committees and the other members of your society, we jointly recognize this problem. But they are the largest group and they have done the most in trying to improve their professional capability to serve the country.

So I think in keeping a little balance in the future, we need to recognize that this is a very dynamic situation, a very dynamic problem. We have a role to play, but we have a role to play in the way we don't interfere with medicine. We certainly find radiation a very wonderful tool in the practice of diagnostic medicine as well as curative medicine.

So I think these are my comments. And, Dick, I think there is one thing that you might wish to confirm, that is the representation of your group nationally for all technologists. I think there is a limitation here, and it is well to make this clear.

MR. FRANKEL: Thank you, Arve.

I have been asked to very briefly summarize what has happened in the past hour and a half.

As you can see, there has been a great deal of controversy, disagreement--in all due respects to all members of the panel and the audience--honest disagreement. But yet, on the other hand, I must note that there has been apparently one point of complete agreement. I have heard no one speak up publicly against the concept of having people who use ionizing radiation in the healing arts as qualified as possible.

With this concept in mind, I am going to turn the meeting back over to Dr. Miller for adjournment.

(Whereupon, at 12:20 o'clock, p.m., the meeting recessed, to reconvene at 1:30 p.m. the same day.)

NUCLEAR FACILITIES AND THE ENVIRONMENT

PANEL: POWER REACTORS AND THE ENVIRONMENT

Moderator: Ernest D. Harward[1]

DR. MILLER: Welcome back to another current and also controversial program area. I feel this afternoon's session will be very interesting and enlightening and, I am sure, very informative to all of you.

I have asked Dave Harward of the Division of Environmental Radiation, Bureau of Radiological Health, to moderate this panel on Power Reactors and the Environment.

MR. HARWARD: It gives me a great deal of pleasure this afternoon to have the honor to moderate a distinguished panel of representatives from six State health departments and the Atomic Energy Commission to talk to you about a subject that is certainly a focal point of public interest around the nation today.

The first speaker this afternoon has been engaged in one of the controversial areas of the United States as far as nuclear reactors are concerned. The Vermont-Yankee plant is being built near Brattleboro, Vermont, and has been the target of many anti-nuclear groups and conservationist forces in that part of the country. Harry Ashe from the Vermont Department of Health will give you his view of what has been taking place in the State of Vermont. I think you can apply what he has found in the State of Vermont generally all over the country because the character of these problems has been very similar.

Harry.

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[1] Chief, Nuclear Facilities Branch, Division of Environmental Radiation, Bureau of Radiological Health, Public Health Service.

THE ENVIRONMENTAL CONTROVERSY

Harry B. Ashe[1]

As I contemplate this subject, I am reminded even a fish wouldn't get in trouble if he kept his mouth shut.

Most people agree that the need for electricity is growing rapidly. Our increasing population coupled with new uses for electricity require a doubling of available electrical energy every 7 to 10 years, and at this rate of growth a 500-600 percent increase will be needed by the year 2000.

There are environmental problems associated with production of electricity from all sources, but the spotlight is presently focused on nuclear power. The utilities and the AEC are under heavy attack from many directions. Physicians, medical personnel, engineers, ecologists, conservationists and many special-interest groups are propounding an ever-increasing barrage of statistics, warnings and dire predictions.

Some of the issues being debated are:

1. Thermal pollution. About two-thirds of the energy generated in a nuclear power plant is waste heat and this is discharged to the environment by the turbine condensor cooling water. For example, at Vermont-Yankee which is a 540 MWE boiling water reactor, a total of about 350,000 gallons of water a minute will be required for the turbine condensors. The temperature of this volume of water will be raised about 20 degrees Fahrenheit before it is sent to the cooling towers or returned to the river.

2. Reduction in maximum allowable quantities of radioactive material released to the environment.

Many people feel that the AEC limits specified in Part 20 of Title 10 of the Code of Federal Regulations should be reduced at least 10-fold.

3. Reconcentration of certain nuclides in aquatic organisms.

4. Long-term effects of tritium and krypton-85.

5. Outlawing of boiling water reactors.

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[1] Director, Industrial Hygiene Division, Vermont Department of Health.

6. Repeal of the Price-Anderson Act which indemnifies the utilities against single losses up to $560 million.

7. Separation of the regulatory and promotional activities of the AEC.

8. The rights of States to set standards lower than those specified by the AEC. In this regard, nationwide attention is on the legal battle between the Minnesota Pollution Control Agency and Northern States Power Company over Minnesota's declared right to enact stricter standards than those imposed by AEC.

I might add that Governor Davis of Vermont is supporting the State of Minnesota and that our Attorney General is entering the legal proceedings as a "Friend of the Court."

There are, of course, many more issues and side issues.

Although the nuclear discussions are being heard in many parts of the country, I will direct my remarks mainly to New England and particularly to Vermont which appears to be the center of the controversy.

In New England, Yankee at Rowe, Massachusetts, and Connecticut-Yankee at Hadden, Connecticut, are operational. Millstone Point #1 is nearing completion and Millstone Point #2 is under construction. Pilgrim at Plymouth, Massachusetts, and Maine-Yankee at Wiscasset, Maine, are also under construction.

Public reaction to these plants has been negligible. Site selection and preparation, construction permits and operating permits at Rowe-Yankee and Connecticut-Yankee, have been routine. Only at Vermont-Yankee has there been opposition.

Only token resistance to Vermont-Yankee was noted at the initial hearing before the three-man Atomic Safety and Licensing Board, but the pot began to boil at the next step in the proceedings which was a hearing before the Vermont Water Resources Board for a permit to use the Connecticut River for cooling water.

As a result of this hearing, the Water Resources Board set down a list of requirements which Vermont-Yankee must meet. Among these was a zero degree allowable temperature rise in the discharge to the Connecticut River during the summer when water temperature is 70 degrees Fahrenheit or higher. This has required Vermont-Yankee to install large cooling towers at a cost of $10 million which will permit the plant to operate on a closed cycle during the summer.

Two years ago Central Vermont Power purchased a large tract of land on Lake Champlain about 25 miles south of Burlington in the town of Charlotte. The implied, if not announced, intent was the construction of a second large base load plant presumably of nuclear design. This action, of course, intensified public reaction.

The initial concern of a relatively small group in the Brattleboro area spread to a larger group dedicated to the preservation of Lake Champlain, to conservationists, to biologists and ecologists, to universities and colleges, to our State legislature, to the Governor, and even to our Congressional delegation.

One direct result of the controversy, I think, was the adoption of a law by our 1969 legislature which requires a certificate of "public good" from our State Public Service Board before any power plant, nuclear or fossil, can be constructed in Vermont. Incidentally, this law also requires Public Service Board approval for transmission lines.

I don't know at what point the AEC decided to improve its public image, but when Governor Davis and Senator Aiken invited them to hold public meetings in Vermont to discuss the alleged dangers of atomic energy, they readily consented.

The Vermont Nuclear Power Town Meeting was held last September 11 with about 40 of the top AEC personnel in attendance including Commissioners Ramey and Thompson, and was highlighted in the evening with an address by Chairman Glenn Seaborg.

Present for the "environmentalists" were Drs. Dean Abrahamson of the University of Minnesota, Clarence Carlson of Cornell University, Ernest Tsivoglou of Georgia Institute of Technology and Arthur Tamplin of the Lawrence Radiation Laboratories.

The meeting is history and the transactions are available to those who are interested. Time doesn't permit details, but perhaps a few comments of my own will be of interest.

First, in my opinion, the outstanding feature was that for the first time the AEC came out of their Washington sanctuary with their top officials and met with their critics on a common platform.

I don't think they did very well. Too much time was devoted to long speeches and too little time devoted to answers. And there was nothing new in the presentations--no new questions and no new answers.

To those of us who have attempted to follow the literature, it was a rerun. To the general public who came for information and assurance, it was too scientific.

The public was bored with the two hours of presentations and disappointed with the one hour of confrontation. About 100 questions were submitted by the audience and less than a dozen answered. Most of these were couched in language that puzzled the layman.

Hopefully, this meeting will lead to others with different formats, with frank and open discussions, and with presentations in words and examples that the public can understand.

Is nuclear power safe?

Is our environment going to be contaminated with radioactivity and ruined by hot water?

This is the nuclear controversy.

Possibly only experience with the new generation of large reactors will provide unequivocal answers, but even with experience, the public will badly need factual, balanced and honest discussions of the problems. Only then can the controversy be laid to rest.

MR. HARWARD: Thank you very much, Harry.

Does anyone have any questions they would like to direct to Harry about this subject?

There is one question that I would like to direct to Harry if he wouldn't mind.

One of the observations that I have made for the past couple of years is there has been a general redirection of the public's concern over nuclear power. A few years ago, all you would hear about were the disasterous consequences of the operation of nuclear power plants. Today, this doesn't seem to me, anyway, to be as much of a problem as the public's general concern over the long-term discharge of radiation to the environment.

Harry, I wonder if you would care to comment on your opinion of the perspective in Vermont, whether it is really the safety question or is it the long-term environmental question that seems to be bothering most people?

MR. ASHE: I think we have several groups in Vermont that are concerned about nuclear power. One is a group that is violently opposed to it. And the only thing they are going to even listen to is some material which downgrades nuclear energy.

There are a couple of books that you may be familiar with--The Careless Atom and The Perils of the Peaceful Atom. These are their bibles. They believe anything they read in them. Anything anyone says to the contrary, they consider a misstatement of fact.

You have another group of people that, I think are honestly concerned and are trying to listen to the scientific people who are groping for answers. They are concerned because the ecologists and the conservationists are asking questions that apparently there isn't any answer to.

I think many of us, and this includes myself, believe that we have many dedicated scientists who are really concerned about nuclear power. I don't believe that all of the people raising questions are irresponsible. I think they believe that there are problems associated with nuclear power. And I think that many people in Vermont are waiting for somebody to come up with some real answers.

We have some people in the Vernon area who are raising the questions of sabotage and other people who are worried about an extinct volcano coming to life because of the Northfield pump storage, a planned water reservoir south of the plant site.

One of the questions I am frequently asked is: If this new nuclear power plant is safe in Vernon, Vermont, why can't they build one in New York Harbor. Truthfully, I have no answer to that question. But all in all, I think that most of the people in Vermont are unexcited. By unexcited, I mean they aren't rising up to the point of violent expression. I think that all of us are looking forward to plentiful electrical energy in Vermont and satisfactory means of obtaining it.

Everybody in the State is becoming increasingly conscious of our environment, and many people also deplore the smoking stacks which are associated with some of our fossil fuel plants. Perhaps if you were to take a vote, the majority would vote to put the nuclear power plants in Massachusetts and New York. I don't wish to comment on that.

MR. BUTLER: Frank Butler, Southeastern Lab.

Mr. Ashe, I was wondering what the answer was that the AEC gave about the release of radioactivity around the reactor. Did they indicate none or some or were they so technical that that was the trouble about biological significance?

MR. ASHE: I don't think that anyone from the AEC made remarks that there wouldn't be any release from the power plant, but there were not any of them that I know of that were willing to say that such releases were going to be of any significance. They will all tell you that once these releases are sent to the environment they will be well below the limits of 10 CFR 20, and that the most vigilant surveillance system will never find any traces of them.

MR. SHAVER: Shaver, North Carolina.

What is the status of Vermont-Yankee right now?

MR. ASHE: Vermont-Yankee expects to fuel initially about next January.

MR. HARRIS: Harry, do you get any reaction to this concept that Congressman Jonathan Bingham has thrown out that the Public Health Service ought to be given more responsibility rather than the Commission so that public acceptance will be enhanced?

MR. ASHE: There are a number of people that are talking about nuclear power; and people at the university level who are interested in it, who quite firmly believe that the regulatory powers and promotional activities of the AEC should be separated.

MR. HARRIS: Or transferred?

MR. ASHE: Yes.

And, of course, the Bureau of Radiological Health, the Public Health Service, has been talked about as the agency for the regulatory program.

MR. CLARK: Wilson Clark, Environmental Action, Washington, D.C.

Do you believe that the minimum standards for reactors should be applied, the standards that are considerably lower than the AEC standards? Do you think this should be applied in the Vermont-Yankee example? Do you think that work should be directed toward that, toward lowering the current standards, say, for example, under 10 CFR 20?

MR. ASHE: I have attended several meetings of the utilities. For instance, I went to Oregon last fall to a meeting where these matters were discussed. Every reactor operator will tell you that his emissions to the environment are going to be something in the order of 0.01 of 10 CFR 20. I personally believe if they can operate a plant with this order of radioactivity released to the atmosphere, that they shouldn't have any trouble working with 0.1 of part 20.

MR. CLARK: In other words, do you believe the standard should be set up on the minimum example or can a substantially lower release rate be achieved under the current AEC standard?

MR. ASHE: I believe that the plants can operate at lower than part 20. And I think that the public will be greatly reassured if these limits are reduced.

But there is one thing I do want to make clear that as far as I am concerned, State health departments haven't any business in the control room of a nuclear reactor. I think that this is something that belongs to the people who very definitely know what they are doing.

MR. CLARK: Who do you think should make this sort of judgment for the population? It is my understanding that, for example, the departments that are doing it now are, of course, trying to do it in the best interest. But there seems to be some conflict between the AEC and the State of Minnesota here.

MR. ASHE: Probably Dr. Lawson can answer this better than I, but I believe that the AEC are the people who should lower these standards. I don't believe that Minnesota and Vermont and Massachusetts and Connecticut should all have different standards. I think there should be uniform standards of releases for all reactors. And I think the Atomic Energy Commission or whatever Federal agency has the regulatory powers should be responsible for those standards.

MR. CLARK: Do you advocate lowering the current AEC standards, say, to the levels that have been recommended by the State of Minnesota?

MR. ASHE: I think they can be lowered, yes.

MR. CLARK: Should they be lowered?

MR. ASHE: I think they should be lowered. Whether the standards as proposed by the State of Minnesota are the ones which should be adopted, of that, I am not sure. But I think they should be lower than they are at present.

DR. PARROTT: May I suggest this is not a press conference. We have got a lot of work to do.

MR. HARWARD: The next speaker I have the honor of introducing is from a State where the impact of nuclear power, commercial nuclear power, hasn't really been felt, but it will be very much so in the coming years. Arnold Moen from the Washington State Department of Health will talk to you about the subject of reactor site selection.

Washington is one of the first States to adopt a committee, a Governor's advisory site selection committee, to look at sites for future power plants in that State which is something we in the Bureau of Radiological Health think is a good policy to follow, working with the utility companies, power companies, working with State officials, AEC officials, and looking at future sites that might be adapted for nuclear power in the future.

Arnold, would you give us the views of the Washington State in this area?

REACTOR SITE SELECTION

Arnold J. Moen[1]

Washington State has been involved with nuclear reactors since the Manhattan Project built the Hanford complex of reactors along the Columbia River at Richland, Washington, in the early 40's. The purpose was strictly military at that time. Washington State cooperated with other State and Federal agencies in environmental studies and sampling particularly around the Hanford area and along the Columbia River from the site downstream and into the Pacific Ocean. These activities were coordinated through an organization called the Columbia River Advisory Group in which the AEC, USPHS and the Oregon and Washington Health Departments were represented. Sampling and analysis were done and so arranged to complement the total program with as little duplication as practically possible.

The peaceful use of atomic energy evolved over the years. Washington State has been in the position of having so many hydroelectric sites available that nuclear reactors for electric power were not seriously considered until these hydroelectric sites had been fully developed. The ever increasing demand for electric power, however, has now reached the point where other sources of power must be developed. Thermal power plants using fossil fuels or nuclear energy have become the "way to go."

The 1961 Washington Legislature enacted the Nuclear Energy and Radiation Act (Chapter 70.98 RCW) establishing the Radiation Control Agency with sole authority for the control of ionizing radiation and delegated this authority to the State Department of Health.

Nuclear energy promotion and development was established as a responsibility in the State Department of Commerce and Economic Development, and is the Office of Nuclear Energy Development. The general powers and duties of this office were:

1. To advise the Governor and the legislature with regard to the status of nuclear energy research, development and education, and to make recommendations, to the Governor and the legislature, designed to assure increasing progress in this field within the State.

2. To advise and assist the Governor and the legislature in developing and promoting a State policy for nuclear energy research, development, and education.

3. To sponsor or conduct studies, collect and disseminate information, and issue periodic reports with regard to nuclear energy research,

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[1] Head, Radiation Control Section, Washington State Department of Health.

development, and education and proposals for futher progress in the field of nuclear energy, and the power to acquire land and facilities for such purposes is specifically delegated to the department.

4. To foster and support research and education relating to nuclear energy through contracts or other appropriate means of assistance.

5. To gather, maintain, and disseminate available information concerning appropriate sites throughout the State and the advantages of locating nuclear energy industries within the State.

6. To keep the public informed with respect to nuclear energy development within the State and the activities of the State relating thereto.

This legislation also established an Advisory Council on Nuclear Energy and Radiation consisting of seven members appointed by the Governor. Membership to include, but not be limited to, representatives from industry, labor, the healing arts, research and education. This is known as the Governor's Advisory Council, and its main function is exactly that--to advise the Governor on matters of nuclear energy. They review and evaluate State policies and programs relating to the development, utilization and regulations of sources of ionizing radiation.

Also established was the Technical Advisory Board on Radiation Control (TABRAC), a nine member board appointed by the Director of Health, with the approval of the Governor, to advise the Radiation Control Agency on matters of policy, technical advice, regulations, and administration of the regulatory program. Representatives were to be from the healing arts, research, industrial, other recognized users and experts in the physiological effects of ionizing radiation.

In 1966 the Governor's Advisory Council suggested to the Governor that a power plant siting task force be established to evaluate and advise on problems relating to the selection of nuclear power plant sites.

Washington became an Agreement State on December 31, 1966. A legislative committee, called the Joint Committee on Nuclear Energy, was established by the 1967 legislature. The senators and representatives on this committee were interested and active in the promotion of nuclear energy development from a State viewpoint. Also involved was the Western Interstate Nuclear Compact and Federal agencies, particularly the Bonneville Power Administration.

Through many meetings with State, regional, and Federal agencies and the utilities, both private and public, it became clear that some mechanism was necessary whereby the utilities could become informed and be assured that a particular plan or site would meet all statutory requirements and satisfy all associations or agencies from a social, technical, or environmental standpoint. The utilities expressed great interest in the establishment of a single body or voice that could speak to them as representing the final authority in the State on the approval of nuclear power plant sites.

The Battelle study of nuclear power plant sites, commissioned by the Bonneville Power Administration, was published in 1968. Some 17 sites were evaluated, including 8 in Washington State. In December 1968, the Grays Harbor PUD proposed a nuclear power plant site on the Pacific Ocean. This was soon followed by other proposals in Western Washington.

This brought an urgency to the matter of State action. At the Governor's Advisory Council's recommendation and with endorsement by the Joint Committee on Nuclear Energy, the Governor hired a consultant to review the situation in Washington and offer recommended procedures. Based on these recommendations, the Governor, by executive order in July 1969 established the Interagency Thermal Power Plant Evaluation Council composed of representatives from 10 State agencies for the purpose of evaluating the impact of proposed thermal power plant sites on the environment and on the natural resources. Represented on the Council were the State Departments of Fisheries, Game, Water Resources, Water Pollution Control, Air Pollution Control, Parks and Recreation, Commerce and Economic Development, Health, Interagency Committee on Outdoor Recreation, and the Planning and Community Affairs Agency.

In announcing the Council, the Governor stated the policy, which was to serve as a guide for the Council's efforts, to preserve and protect the quality of the environment, and to assure Washington residents that operational safeguards consistent with established Federal and State criteria would be technically sufficient for their welfare and protection. He explained that the State recognized the role of the AEC in the areas of seismic and radiological safety. He stressed that each proposed site would be evaluated separately but would also be related to other sites in close proximity.

The Chairman of the Council or the Governor shall be the only official spokesman for the Council itself in respect to any proposal under evaluation. The Chairman, plus whatever representatives he deems will be needed to provide the necessary expertise should represent the State at Federal hearings for construction or operating licenses.

It soon became clear that this Council would need a legal standing with more authority than could be invested in a Council created by executive order.

Consequently a bill was drafted and submitted to the 1970 special session of the legislature. The bill was modified slightly by the legislature but did pass and was signed into law by the Governor on February 23, 1970.

Summarizing the bill, I believe, the main points of interest here would be the following:

1. The establishment of a legal voice that can speak for and present the State position with regards to the location of a thermal power plant in the State of Washington. The Governor stated in his letter of approval: "This act establishes a procedure for evaluating and certifying proposed sites for thermal power plants in the State of Washington. Under present law, there is no set procedure in State government for reviewing an application to establish a thermal power plant facility. An applicant seeking to establish a plant, whether the applicant be a private industry or a unit of government, must now deal separately with a number of different units of government. The principal purpose of this act is to coordinate the interests and activities of each unit of State government that plays a role in the establishment, location, and operation of such a facility so that the State can have a unified position."

2. Certification by the Thermal Power Plant Site Evaluation Council means a binding agreement between an applicant and the State regarding the location of a proposed thermal power plant and associated transmission facilities.

3. Membership of the Council is composed of the same 10 agencies mentioned before plus 5 others; namely, the Department of Agriculture, Civil Defense, Natural Resources, the Utilities and Transportation Commission, and a representative of county government.

4. The Council is to develop and apply topical environmental and ecological guidelines in relation to type, design, and location of thermal power plant sites and associated transmission line routes.

5. Receive and investigate applications for site locations including independent studies, when deemed necessary, to determine the impact on the environment.

6. Conduct public hearings on the proposed location.

7. Report to the Governor in writing a statement indicating whether the application is in compliance with the Council's topical guidelines, the criteria to that specific site, the means of monitoring the effects arising from the construction and operation of thermal plants on the site and the Council's recommendations as to disposition of the application.

8. The Council's certification is required of any thermal power plant with generating capacity of 250 megawatts or more before any construction is initiated.

9. A $25,000 fee is to be submitted with each application.

10. The Attorney General shall appoint an assistant attorney general as a counsel for the environment to represent the public and its interest in protecting the quality of the environment for each application.

11. The Council shall report its recommendations to the Governor within 12 months of the receipt of the application.

12. The certification shall be in lieu of any permit or similar document required by any department of State government.

The topical guidelines of the Council were drafted by the Council and presented at a public hearing on April 3, 1970. This hearing was recessed to May 4, 1970 for formal adoption of the guidelines.

Testimony at the April 3 meeting plus written comments received before April 24 will be considered by the Council on April 30. The draft developed on April 30 will be presented at the May 4 meeting.

The guidelines summarize all the items pertaining to the location of a thermal plant that are now statutory requirements. The specific details of these requirements are set forth in criteria developed by each agency of government with an interest in the effects of such a plant on the environs.

For example, the Health Department Radiation Control Section has developed criteria to define the specifics of radiological monitoring requirements prior to, during construction and operation of the plant. The State recognizes the Federal preemption for radiological safety of the plant itself. These criteria pertain to the assurance of the public that these effects on the environment will be measured and that the public health and safety are protected to the fullest extent practicable.

The whole concept of the Council and its functioning is planned to be flexible enough to change as the need arises and as more applicable approaches to the problem develop. It is hoped that it will become accepted as the single voice for the State that will be the decision-making body with final authority and that it will truly represent all segments of the public in preserving the environment to the maximum extent practicable in the location of thermal power plants.

Thank you.

MR. HARWARD: Any questions to be asked of Arnold?

Would you limit your question to one, please, and give everybody an opportunity?

MR. CLARK: What is your opinion as a representative of the Washington State Department of Health about the possibility of a liquid metal fast breeder reactor being placed in the Puget Sound area, a very densely populated area?

MR. MOEN: My personal opinion--I will give you my personal opinion, which will not be the official voice of the State--is that you can place such a power plant in the Seattle area or the Puget Sound area.

MR. HARWARD: Any other questions?

MR. CLARK: If you will permit me, I would like to use a very brief quote from Dr. Karl Morgan, the editor of Health Physics, and one of the founders of the profession.

Dr. Morgan stated before Congress in January in his opinion reactors should not be placed anywhere near populated areas. He stated they should either be in underwater caissons or underground far away from cities.

Dr. Edward Teller, one of the founders of the profession, also stated that reactors should be underground.

Would you please comment on this?

Did I make an error?

(General chorus of "yes.")

Fine. Let me use the quote from Dr. Morgan which was taken from Congressional testimony.

MR. HARWARD: Can I ask how long this quote is, really?

MR. CLARK: I could use two sentences.

MR. HARWARD: If you would, please, limit it to that, I would appreciate it.

MR. CLARK: This is testimony presented before the Joint Committee on Atomic Energy at its hearings on Environmental Effects of Producing Electrical Power, Phase Two, January 1970, by Dr. Karl Z. Morgan, Health Physicist, Oak Ridge National Laboratory, Oak Ridge, Tennessee. Dr. Morgan stated:

> "I believe the risks to man and his environment from nuclear power plant operations are far less than those from fossil fuel power plants. I am of the opinion, however, that at the present state of the art, none of these power plants should be built in very densely populated areas. And in my written testimony, I have suggested that for the present, these plants be built underground or offshore in underwater caissons at considerable distances from our big cities and then in the meantime serious attention be given to the development of more economical methods of power conversion and

transmission to using usefully the waste heat rather than permitting environmental thermal pollution and that engineering improvements be made to assure absolute integrity of the secondary containment provided for these power plants."

Thank you.

MR. MOEN: You have a wealth of material there that I couldn't possibly answer. I wouldn't presume to be qualified to judge Karl Morgan.

As I stated, I gave you my opinion. He has his. We could quote others that have been quoted in Congress and otherwise. I am just reporting on what the State of Washington is doing, trying to gather experts in each field and get their concerted opinion about a particular plant. All these features will be considered at any site evaluation.

MR. HARWARD: Bill Crosby.

MR. CROSBY: If I understood you correctly, I believe this cut-off point was 250 megawatts per thermal power plant, is that correct?

MR. MOEN: That's right, except one qualification--50,000 on a floating plant.

MR. CROSBY: Okay, but use this perhaps as a measure toward proliferation of smaller power plants. Because the rigamarole would seem to try to direct the power company, the private utility, at least, to stay away from this kind of thing, I would think. I wonder if you see this as a pressure in this direction.

MR. MOEN: I doubt that. I have an electrical engineering background, and I worked for the power company. And small plants are not economical.

MR. CROSBY: But they are possible, whereas it might not be possible at all with this thing. That was my thought, anyhow.

MR. MOEN: They are possible, but I doubt that they will actually occur.

MR. HARWARD: I only had one question of Arnold that I thought might be of general interest to the State Health Department people here.

Arnold, what is the fee of $25,000 to cover? Would you comment on that?

MR. MOEN: This fee, as I understand it, is to cover some of the cost in the processing of the evaluation of an application. Some of these will demand studies of a particular impact on environment at that location.

This does not limit the applicant to a $25,000 fee. Any study that is mutually agreed upon above that figure will be paid for by the applicant. $25,000 is a minimum, however.

MR. HARWARD: Thank you very much, Arnold.

I would like to go on to the next speaker now. It is a real pleasure this afternoon to introduce Dr. Warren Lawson from the Minnesota State Health Department.

Whenever one hears the word Minnesota these days, one immediately thinks of the controversy up there relating to the Monticello plant. The Monticello plant is having its AEC construction permit hearing this week. And we will be awaiting the results of that. In the meantime, Dr. Lawson is going to discuss the question of State standards as related to nuclear power.

STATE STANDARDS

Warren R. Lawson, M.D.[1]

What I propose in my presentation is to recapitulate for you the situation regarding nuclear reactors in Minnesota and to make some general observations about these matters.

Minnesota began to have its first experience with a reactor back in the late 1950's when the Rural Cooperative Power Association of Elk River, a small cooperative power company, was the first successful candidate in the first round AEC power demonstration program. This facility became operative in about 1960. It was a boiling water reactor and had an output of about 40,000 KW.

At that time, the only agency in the State that took any interest in this matter of reactors was the State Board of Health, and the State Board of Health, operating through its arm, the Minnesota Department of Health, participated in the review of the design of the waste handling facility for this reactor.

The staff of the Department also helped design the preoperational survey which was actually contracted to the University of Minnesota School of Public Health with the Department's laboratory serving as a verification laboratory. We also designed and entered into a contract with the RCPA and AEC for operational monitoring in-plant and off-site for the years that this plant operated

The RCPA reactor operated on and off, mostly off, for about eight years and was finally shut down permanently in 1968 at which time the power company concluded it could not be operated economically in their small power system.

This facility during its design, construction and operation phases had its opponents, but most all of this opposition came from isolated individuals, with relatively little group organization.

The principal basis for contention was that since it was a power demonstration reactor, it was, therefore, an experimental reactor having all the hazards of an experiment. As a generally secondary issue, some opponents argued that the siting at a point on the Mississippi River about 15 miles upstream from Minneapolis-St. Paul where about one million people were drawing their water supply was an unsafe location.

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[1] Medical Consultant, Occupational Health and Radiation Control Units, Minnesota Department of Health.

The RCPA reactor is now history. The least one can say about what we learned by this experience was that the concept of small reactors for small commercial power production was, at best, dubious.

Secondly, we learned that the design data regarding the liquid waste discharges that were anticipated were in error by a factor of about 30.

The RCPA was never licensed by the State of Minnesota, although regulations of the State Board of Health do require licensing, the reason being that the reactor was always the property of the Federal government, not subject to State licensure. The AEC, however, more or less, and the power association generally, cooperated pretty well with the Department of Health and the Board in providing all of the information required by the Board's regulations.

With this general experience, the Department of Health and the State Board of Health have been somewhat more comfortable in facing the prospects of a large reactor at Monticello, Minnesota, in the immediate future and at least two more large reactors in the next ten years. But unlike the situation ten years ago, there are many agencies and many individuals who are now opposing power production by nuclear means.

The Monticello reactor itself is being constructed by Northern States Power Company. This is the major power company in the State of Minnesota supplying electrical needs to the lower half of the States which includes the metropolitan area of Minneapolis and St. Paul, generous parts of Western Wisconsin and eastern parts of South Dakota. NSP has had some experience with reactors. The Pathfinder facility at Sioux Falls, South Dakota, was built by NSP. Pathfinder has been closed, primarily for mechanical reasons, especially relating to the operation of the superheater. This reactor will not be activated again, but will be used as a training facility for future NSP reactor installations.

The Monticello reactor is a single-cycle boiling water reactor without superheat. It will have an ultimate capacity of 550,000 KW. It will be fueled with 200,000 pounds of uranium, slightly enriched with U-235. This will be assembled in 484 fuel assemblies, each containing 49 fuel tubes, the equivalent energy being contained therein is about 7 million tons of coal.

The cost of the installation for the plant alone is in excess of $75 million with additional $5 million for substation and transmission outlets.

Site preparation began in 1967, and the plant will be ready for testing in August this year. The site, again, is on the Mississippi River about 40 miles upstream in the northwesterly direction from Minneapolis-St. Paul area.

The area is generally flat and heavily committed to farming. The largest town in about a 15-mile radius is Monticello, Minnesota, approximately three miles to the east. The river has an average flow of about 4600 cubic feet a second. Low flow is about a tenth of that and maximum flow is about 10 times that. There is relatively little recreational use made of the river along this section.

The geology of the area is generally sandy with several layers of glacial till about 50 feet deep overlying the base rock.

Meteorologically, Minnesota is characterized by rapidly changing weather patterns. Wintertime winds are predominantly from the northwest, summertime winds predominantly from the southeast.

The statutory authority to the State Board of Health in the matter of reactors and ionizing radiation generally was granted in 1957 by the State legislature. The law is quite simple. In essence it states that:

> "The Board may promulgate regulations and/or may be requiring the taking out of licenses or permits or by other appropriate means control the sources of ionizing radiation and the handling, storage, transportation, use and dsposal of radioactive isotopes and fissionable materials."

In 1967, 10 years later, the State legislature reorganized its law relating to air and water pollution control and created an entirely new agency known as the Minnesota Pollution Control Agency. This Agency consists of nine members appointed by the Governor and a director who was also appointed by the Governor.

The Agency functions through its director who has a staff of about 70 technical and clerical people. The Agency members at the present time consist of the University professor from the Geography Department, a retired Air Force colonel who was in charge of radar installations, a retired banker, a practicing lawyer, a Mayo Clinic chest specialist, a retired paper mill executive, a farmer, a housewife and a small buisnessman.

This law in Minnesota has a peculiar twist in that it requires that there be an agreement drawn between the Agency and the Board of Health whereby the Board will provide and will be reimbursed for services rendered to the Agency. Many of these are detailed operational services, the most important ones, however, being laboratory and field investigation services.

The pollution control laws make no mention of radioactive materials or waste, but certainly such matters could be inferred within the scope of the Agency's responsibilities. And therefore, we have a considerable confusion.

On this general background, then, I would like to spend a few minutes recounting the courses of events about the present controversy in Monticello. The Northern States Power Company kept the Minnesota State Board of Health and the Department of Health fully informed during all stages of the preplanning, planning and design of the nuclear Monticello facility. All information and documentation relating to radioactive waste levels, waste handling procedures, that were to be anticipated normally, and during abnormal occurrences were furnished to the Board and staff.

The Board requested the assistance of the Nuclear Facility Service of the Public Health Service in evaluating the public health aspects of this facility. Such a report was rendered and in 1967, the State Board of Health, depending upon its staff recommendations, the report of the Nuclear Facilities Section, and its own advisory committee on radiation safety, concluded that the construction and operation of the facility would not involve a risk to the health and welfare of Minnesota residents.

The Department also proceeded at that point, to design the preoperational environmental survey and it actually conducted the survey which commenced in June 1969 financing these operations from a gift by Northern States Power to the State of Minnesota for these purposes.

In essence, then, the Board by its actions has accepted and adopted the standards and the design parameters of the Atomic Energy Commission for this facility. The MPCA, the Minnesota Pollution Control Agency, as I said, came into existence in July 1967. Actually, it did not get into business until 1968 at which time the Northern States Power Company immediately applied to them for a permit to discharge liquid and gaseous waste. The Agency quite understandably, being a new agency, temporized. And, as the Agency continued to temporize over the next several months, opposition to the facility grew by leaps and bounds and the Agency found itself in the middle of a controversy which was centered really around the question of adequacy of AEC standards and the old question of a single agency promoting and regulating at the same time.

This opposition centering in a number of very active individuals and a number of small conservation groups began to exert strong pressures on the Agency not to permit any discharges of radioactivity into the environment. A great number of articles also began to appear in the press, and as the Agency continued to delay its decision, opposition to the facility attracted more and more publicity.

Practically no meaningful dialogue developed between the technical radiation control staff of the Department of Health and the Agency during this period. And presumably, this was due to the fact that the recorded action of the Board and its staff constituted a commitment and from some viewpoints a capitulation to the AEC.

There were a number of very interesting things that happened along the way, and I will only relate one. This is the story of the radioactive clams.

A sophomore in a university class in biology was required to conduct an experiment. He purchased some live clams, collected a couple gallons of water above and below the Elk River reactor and placed the clams in the two samples of water for some period of time. His instructor referred him to someone who had some kind of counting equipment, and he eventually produced a report which immediately became a scandal in the press, reporting higher levels of radioactivity in the clams above the reactor than below.

The poor student, a short time later turned up in our offices. He was pretty embarrassed and in discussing the matter with him, it was quite obvious he could never have produced the data that he had indicated in his report. He had quite evidently faked the data for purposes of a class report.

To my knowledge, no newspaper or any other media has ever attempted to interview the student or has ever attempted in any way to obtain the facts about this report. Although the Agency and members themselves, the staff and the Director of the PCA, were aware of the truth of this clam study, the records of the hearings and minutes of the Agency meetings were never corrected accordingly.

Well, to continue, at each meeting of the Agency, additional public testimony was received, and the Agency became so divided on this matter that no decision seemed possible at all.

To resolve the dilemma, the Agency decided to employ a consultant. After considerable investigation a contract was arranged with Dr. E. Tsivogolou of the Georgia Institute of Technology.

The contract with him was first to recommend general radioactivity standards for air and water quality standards and, second, to specify the conditions for a permit for the Monticello reactor.

The Tsivogolou report is around 200 pages long. It is quite detailed. I would only like to point out one or two items to you.

I think of most importance in this regard is Dr. Tsivogolou's recommendation that for purposes of selecting standards for radioactivity, any distinction between the individuals and the average members of the population implied a dual standard and that such attitude has as its source the old and generally discarded, he says, concept that persons living in the neighborhood of controlled areas can properly be exposed to radioactive levels somewhat higher by a factor of three than the level regarded as acceptable for an average member of the public.

He, therefore, recommended the MPCA eliminate this distinction as far as its own statewide radioactivity standards were concerned.

The next item of particular interest in this matter is his recommendation that the MPCA radioactivity standards and regulatory program be based primarily on the concentrations of radioactivity in the air and water effluents at the point of discharge, meaning in the stack for gases and in the discharge pipe for liquid wastes.

He indicated in the report that environmental radioactivity concentrations based upon estimates of dose at the site boundary were unnecessarily costly and complex, and he does not regard them as practical or suitable.

It also should be noted that he recommended that where effluents consisted of a mixture of several radioisotopes, the numerical limits for individual isotopes should be reduced according to ICRP and AEC recommendations for mixtures.

Subsequently--that is, subsequent to the issuance of this report--Dr. Tsivogolou did develop a permit for the Northern States Power Company which even was more restrictive than he had indicated for his general standards.

The Northern States Power Company has reacted with two court suits, one in the State court asking that the permit be set aside as capricious and arbitrary and internally inconsistent, and the second is in the Federal courts contending that no State agency has regulatory authority in matters of radioactive waste discharges from nuclear facilities.

It is expected that it will take up to six years to resolve the legal issues involved. In the meantime, the plant will be ready for operation soon.

A hearing is being held today by AEC in Minnesota regarding the operating license. Some compromise will have to be worked out. I would guess that the Agency will permit the facility to operate by AEC standards as its share of a compromise while the Northern States Power Company will begin to design some off-gas containment and storage facilities to help reduce the concentration of radioactive gases discharged in the environment.

The test of AEC authority in my opinion is long overdue. I think this matter ought to be clarified. I personally believe the State and local government units do not and are not likely to have the technical resources necessary to set standards in this complex field. This does not mean the States should not be knowledgeable about standards nor the States should not have the opportunity to review waste handling procedures and systems.

The States should also be heavily involved in monitoring and surveillance systems and in emergency reaction planning, but the entire history of public health, it seems to me, is replete with examples of the advantages of national codes and standards, a few examples of which are the drinking water standard, the milk ordinance code, the threshold limit values of ACGIH and so on.

The general argument that the local conditions dictate a need for special standards does not appeal to me in most situations, and the confusion which results with various States rushing off in all different directions, seems to be a backward step in our complex society.

Thank you.

MR. HARWARD: In the essence of time, I would like to ask that we limit our questions to three. If anyone has any further questions to speak with Dr. Lawson after the session or after the meeting this afternoon.

MRS. MUSGROVE: My name is Martha Musgrove, and I am here representing Nucleonics Week.

We would like to ask Dr. Lawson if he agrees with Dr. Ashe that the AEC could lower its standards.

DR. LAWSON: I don't really want to get into this argument because it is a problem of semantics in my opinion. The standards you are talking about say that permissible limits are thus and such. The industry is now operating at two percent of that limit. so where is the problem?

MR. CLARK: My name again is Wilson Clark.

The question I would like to ask you is in three parts. It will be one question.

The first part is: Do you believe that this is, indeed, a question of semantics or is it a question of safety to the population of the United States?

DR. LAWSON: I think what we are talking about here is a question of semantics. What we ought to be talking about is what are the specific levels we are designing towards and reacting to, not what are permissible levels. That is an entirely different subject in my opinion.

MR. CLARK: As a layman, the reason that I am here at this Conference is simply to try to find out what the position of the profession is in this area. And I would like to make that clear.

The question that I have concerning--is the Monticello reactor a boiling water reactor?

DR. LAWSON: Correct.

MR. CLARK: Here are figures regarding boiling water reactors just published by the Bureau of Radiological Health.

DR. LAWSON: If I haven't read it, I have no comment.

MR. CLARK: I am just going to give you a figure and ask you to comment.

According to the Bureau of Radiological Health, at the Humbolt Bay plant owned by Pacific Gas and Electric, a boiling water reactor, 897,000 curies were released in 1968. Of the total annual gaseous waste discharges, this figure only represents eight percent of the current AEC permissible limit.

This is one of the areas that will be considered in the design of holding tanks to prevent the release of the noble gases at Monticello. For example, an attempt to cut down on krypton-85 releases will be implemented which were referred to in November 1966 in Radiological Health Data and Reports as constituting a very serious danger to the population of this country within 90 years.

Would you comment on this problem of the release, for example, of the noble gases, particularly krypton-85, and use the Monticello example.

DR. LAWSON: Well, my opinion about krypton is that it is of limited biological significance.

MR. HARWARD: Anybody else have a question?

MR. CLARK: I am not asking the question of professional semantics.

MR. HARWARD: I just make one slight comment on this. The krypton-85 question that you are raising is primarily the one associated with fuel reprocessing plants and not with operating power reactors.

One more question. Do we have one from the audience?

If not, we will go on to the next speaker.

Florida is getting its first nuclear power reactor in operation, I believe, in 1971. And the Florida Department of Health has been engaged in a surveillance program preoperationally for this facility for several years now, this being the Turkey Point plant south of Miami, Florida.

To tell us about the State of Florida's radiological surveillance program and their philosophy, we would like to have Mr. Wallace Johnson with the Florida State Board of Health give you the Florida position on this matter.

FLORIDA ENVIRONMENTAL SURVEILLANCE OBJECTIVES

Wallace Johnson[1]

We actually have three nuclear power sites under consideration now in Florida. We will have two units at Turkey Point in Dade County. We will have one unit at Crystal River on the Gulf Coast and a single unit at the Hutchinson Island plant near Fort Pierce.

The stated objectives of radiological surveillance in Florida are:

1. To provide an early warning of the introduction of radioactive materials into the environment through analysis of air, water, milk, and other environmental samples.

2. To evaluate radioactive contamination in food, air, and water by analysis of data generated through sampling, by comparison with guidelines established by the Federal Radiation Council, the National Council on Radiation Protection, and other advisory groups.

3. To establish a radiological reference point (or background) for selected areas of the State as indicated.

4. To assess the influence of major nuclear facilities on the environment and to insure that these operations do not adversely affect the public health.

5. To perform research and development work as necessary.

In a larger sense, these objectives may be stated more concisely in the simple observation that our prime objective is to protect the health and safety of the people of Florida. In order to accomplish this end, any surveillance program must consist of three basic components:

1. An area of collection of appropriate sampling media which will demonstrate the presence of radionuclides in pathways leading to man. A system of analysis must be available which will be capable of detecting concentrations of radionuclides which may be a threat to human health at levels sufficiently below the actual hazard level to permit effective protective action.

2. An area of evaluation of the data produced by efforts in area one. These evaluations should make use of the various recommendations of such advisory groups as the Federal Radiation Council, the National Council on

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[1] Public Health Physicist, Division of Health, Florida Department of Health and Rehabilitative Services.

Radiation Protection, the International Committee on Radiation Protection, and other competent scientific opinion. The critical need of this area is that, whatever "yardstick" of evaluation is selected, a consensus exists within the State as to levels at which protective action is to be undertaken.

3. The third major area of surveillance activity may be simply stated as the "action" area. This action area must be capable of instituting protective measures to interrupt the flow of radionuclides somewhere along the pathway leading to man when competent judgment indicates that the hazard to man is greater than the associated hazard of the protective action.

Any radiation surveillance program which does not contain these three concepts is at best an academic exercise in the collection of data and at worst is an exercise in futility.

Perhaps a fourth area should be added to the foregoing three. This would be the area of program evaluation in which we ask ourselves these questions:

1. Does this program work? Does it really fulfill our prime objective of protecting the public health?

2. Is there a better way to do this job?

3. If the program will work, and if no better methodology is forthcoming, just how much time and money is justified in terms of the risk involved?

An evaluation of question one involves complexities of analysis beyond the scope of this paper. Suffice it to say that the Florida program has served to detect and delineate an anomaly in the distribution of fallout cesium-137 in milk in Florida; to detect and delineate a similar local anomaly in milk of strontium-90; and has served as the framework upon which we have built radiological surveillance programs around three nuclear powered generating plant sites in Florida.

An evaluation of the second question--Is there a better way to do the job?--has produced innovations in Florida which raise rather fundamental questions in themselves.

We have, for example, entered into a grant-agreement with the Florida Power and Light Company to conduct a radiological surveillance program around the Turkey Point site in Dade County, and the Hutchinson Island site in St. Lucie County. The company will utilize the output of this surveillance to satisfy their obligation to the AEC for such surveillance, while the State Division of Health will utilize the output to evaluate the public health impact of the facility.

Sample collection and sample analysis are entirely in the hands of the State Division of Health. The contribution of the company is in the form of donation of certain equipment to the State Radiological Laboratory in Orlando, and of reimbursement of actual expenses incurred in conducting the program.

Today, it appears to be increasingly popular to consider government and industry as antagonists with incompatible aims and goals. We in the Florida radiological health program have not accepted this concept. We believe that industry has a responsibility to protect the public health, and that, as taxpayers in the State of Florida, we represent industry quite as much as we represent private citizens.

We find nothing incongruous in either the fact that industry should properly bear a portion of the special cost involved in protecting the public against certain aspects of their operation, or that they should utilize the facilities of a State program to accomplish this end.

Further, since the State Division of Health could not abrogate its responsibility to maintain protective surveillance, in favor of either industry or consultants retained by industry, we feel that we are not in competition with private enterprise. The question is not whether a State agency has supplanted a private consultant in a program, but rather will there be one program or two. We find no rationale for requiring citizens of Florida to pay for two surveillance programs in order to promote private enterprise.

We do hasten to point out that the State Division of Health has not entered into a similar arrangement with another Florida utility regarding its nuclear power plant site. Our environmental surveillance around this site is nevertheless similar in size and scope to that around the other two sites.

An important innovative concept of this program is the construction of a standardized surveillance system around all power reactor sites in Florida. Such standardization permits intercomparison of data and the accumulation of a "data bank" on radiological characteristics of large areas of the State which would be otherwise unavailable.

It is our opinion that State-operated surveillance plans around private reactor sites, with a portion of the cost borne by industry, may be an answer to the problem of a burgeoning power industry, and will most certainly provide a better grasp of multi-siting problems such as river basins and estuaries will present in the future.

An answer to the third program evaluation question involves areas of philosophy and of honest differences in scientific opinion. At one extreme is the idea of a completely source-oriented surveillance in which monitoring of releases of radioactive materials is the only surveillance actively conducted.

A more conservative approach would be to combine environmental surveillance with source monitoring basing environmental sampling media and frequencies on measured releases of activity.

The third approach is to sample "everything in the environment" all of the time. In Florida, we have not been required to make this decision as yet since we do not have an operating power reactor at this time. We expect operation at Turkey Point next spring.

It is obvious that in preoperational programs a source-oriented program is not pertinent. What is pertinent is the question of what media and what frequencies of sampling are required to establish the radiological characteristics of an area. The answer to this question, in large measure, will reflect the area being sampled in terms of critical pathway and critical nuclides. Our objective in Florida is to investigate the obvious food chain pathways to man.

Further, however, because of known anomalies in the distribution of certain radionuclides, we feel that a statistically valid sampling of such non-food chain items as soil, and such vegetation as our native palmetto may reveal evidence of anomalies in the area.

We found one such anomaly in connection with surveillance around one of our plant sites where we were sampling palmetto in the absence of any other form of vegetation. This was at our Crystal River site on the West Coast. We find that we have high levels of cesium-137. And as fate would have it, these high levels are closest in to the plant at our sampling location.

Now, if we had missed this in our preoperational surveillance, this would have presented some problems in the operational phase. This type of information, obtained in the preoperational sampling program, will be of considerable value in evaluating data from the operational phase, and a completely food-chain oriented sampling protocol would not have produced this information.

We have attempted, briefly, to outline the objectives and something of the philosophy of radiological surveillance in Florida. In doing this, we have confined our attention largely to the question of these objectives as applied to nuclear power reactor sites. But I would not like to leave you with the impression that we have focused our attention entirely upon the question of utilities. We are growingly concerned with the impact on the environment of "multi-sited" licensed activities which contribute to local environments.

We have, for example, in the Miami area 22 nuclear medicine licenses in hospitals. We questioned whether the impact of these 22 nuclear medicine licenses on the environment may not present quite as much of a problem as the impact of the Turkey Point nuclear power plant. We don't have the answers to these questions yet. We intend to have them.

But it is our opinion that the day is not far away when release limits must be applied on a regional or a national basis rather than on a facility basis. And to that end, we are devoting much of our research and development.

Thank you.

MR. HARWARD: Thank you very much.

Do we have a question?

MR. CLARK: As a representative of the State of Florida, would you follow Mr. Ashe's example in recommending that 10 CFR 20 limits be lowered?

MR. JOHNSON: My answer to this question is this: We do not in Florida set ourselves up to judge. We evaluate, but do not judge. We evaluate, but do not judge 10 CFR 20.

The reason I am answering this question this way with all respect to the AEC is that we judge releases in Florida on the basis of the State of Florida regulations.

MR. CLARK: May I ask one question? If you do not judge 10 CFR 20 limits as a representative of the State Health Board of Florida, who in this State is judging 10 CFR 20?

MR. JOHNSON: I don't know.

MR. CLARK: Do you think this question should answered?

MR. JOHNSON: Not by me.

MR. CLARK: Who then will answer this question?

Of all the assembled bodies, both Federal and local in this country, who is supposed to answer this question?

MR. JOHNSON: Young man, as you pointed out, I represent the State of Florida. I will be glad to discuss with you the State of Florida regulations which we do evaluate at any time. I think some other time might be more convenient.

I am simply saying that we are not judging the AEC simply because we operate under the State of Florida regulations and State of Florida law.

MR. CLARK: Just one last thing: Are you concerned that the State of Minnesota has already set up standards that are considerably lower than the AEC standards? Does this concern you as a representative of the State of Florida.

MR. JOHNSON: Not at this point.

MR. CLARK: Thank you.

MR. HARWARD: Any other questions?

Well, if not, we will go on to the next speaker on the program.

One of the reasons the designers of this Conference put California at the particular place in the program was if Si Kinsman happened to come and speak for John Heslep, we might get a good break by having a real fine joke. So Si Kinsman is going to tell us about the California Surveillance Program which is, as you will see, considerably different in philosophy from the Florida program which you just heard about.

Si.

CALIFORNIA ENVIRONMENTAL SURVEILLANCE OBJECTIVES

Simon Kinsman, Ph.D.[1]

Thank you, Dave.

I wasn't sure you were going to announce it, and I thought I better let them know in case they didn't know this wasn't John Heslep up here.

John asked I extend his regrets. He was unable to make it. He wanted to be with you. There are a number of people in this group he had worked with when he was Chief of the Bureau of Radiological Health and hasn't seen for a long time. He said he would like to come down and renew old acquaintances and if we wrote a speech, he would be glad to do this. We wrote the speech, but he still couldn't make it. So here I am. But that is the situation when you are a public health worker. You can't be in three places at the same time.

The California Department of Public Health's first specific statutory responsibility in ionizing radiation was in 1955 under a radioactive waste disposal law. The law was amended in 1961 and 1965 and entitled "Control of Radioactive Contamination of the Environment," which is now in the Health and Safety Code. The intent of the law is clearly stated as follows:

> "The Legislature finds and declares that radioactive contamination of the environment may subject the people of the State of California to unnecessary exposure to ionizing radiation unless it is properly controlled. It is therefore declared to be the policy of this State that the State Department of Public Health initiate and administer necessary programs of surveillance and control of those activities which could lead to the introduction of radioactive materials into the environment."

And it states further:

> "No person shall operate a nuclear reactor, nuclear fuel reprocessing plant, or other installation, as defined by the Department, which could, as a result of routine operations, accident, or negligence, significantly contaminate the environment with radioactive material, without first instituting and maintaining an adequate program of radiological monitoring. The proposed program shall be submitted to the Department for review and acceptance as to its adequacy."

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[1] Chief, Bureau of Radiological Health, California State Department of Public Health.

With that as the law, you can see why our radiological surveillance program is as it is. We sample the environment completely, and we are sure, we have responsibility for the environment around reactors. We have responsibility for any radioactive material that gets into the environment regardless of the source. And that is the reason we are doing the amount of sampling, shown in the following table:

Summary: Environmental Surveillance
Samplings and Analyses

Media Sampled	Sampling Stations	Sampling Frequency	Yearly Totals Samples	Yearly Totals Analyses[1]
Air	14	Daily[2]	4,224	6,276
Fallout	21	Quarterly[3]	92	368
Water	50	Monthly	600	904
Sewage	20	Monthly	480	960
Milk	10	Monthly[4]	120	360
Diet	20	Quarterly[5]	80	520
Snow	12	5/year	60	60
Specials	12	1/year	240	480
			5,896	9,928

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[1] Gamma scan for 8 isotopes reported as 1 analysis above.
[2] 10 stations sampled on work days only; 4 stations sampled every day.
[3] 20 stations sampled quarterly; the Berkeley station is sampled monthly.
[4] Does not take into account increased sampling for continuing atmospheric nuclear tests.
[5] From 1960-64 the individual foods composing a diet were sampled. In 1964 the diet sampling replaced the food sampling.

Now, this is a lot of work, but we think that this is giving us an adequate picture of the environmental contamination. Or this is a proper surveillance of the environment.

Since fallout has ceased to be much of a problem, and since the recommendation of the Conference last year was to orient sampling to radiation sources, pay more attention to the sampling around the reactor and forget the fallout or let it go, we have curtailed this activity to the extent that we have laid off two chemists and an instrument man in the laboratory, and we moved one fellow from the environmental surveillance program to inspection work in the Radioactive Materials Control Section of the Bureau of Radiological Health. We have cut the total samples by about 45 percent.

But we have increased the sampling around the nuclear facilities. I think that this is in order even though we are required to have a sampling program submitted by the facility which is operating a nuclear reactor.

We approve the facility environmental surveillance program for adequacy. We also cross-check our samples. We have split samples or we do a dual analysis to check their results. And we have plenty of evidence that the results are accurate.

Also, the U. S. Public Health Service checks our results with split samples so they are satisfied that the results we give them are representative of the environment in our particular area.

So this is the only difference that I can see with the two programs, the Florida one and ours, in the surveillance. And I am sure the objectives are the same and just the method of working it out is different.

So since the title was objectives in environmental surveillance program, all I would say is our objective is to reduce the radiation exposure to the general public from environmental contamination of the sources such as reactors and so forth so that the total combined environmental hazard will be far below that which the people are receiving from the unnecessary use of medical x rays.

That is our objective. We have secured it for the past two decades, and there is no reason we can't maintain it.

Thank you.

MR. HARWARD: Our next speaker is kind of a bonus speaker because of the recent developments in the AEC's program. Because these developments relating to environmental surveillance and the reduction of waste discharges are of vital interest to the States, we decided to ask Mr. Les Rogers of the regulatory program of the USAEC to tell us about these most recent developments.

PROPOSED AMENDMENTS TO PART 20 AND PART 50 CFR

Lester Rogers[1]

I appreciate your making a spot available so that I might speak with you briefly about the recent proposed amendments to the Part 20 and Part 50 regulations.

As most of you know, the AEC announced on March 27, 1970, issuance of proposed amendments to its regulations in Part 20 and Part 50 to improve the regulatory framework for assuring that reasonable efforts are made to keep exposures to radiation and releases of radioactivity in effluents from light water cooled power reactors as low as practicable.

Limits on releases of radioactive material in effluents from all Commission licensed activities currently are set forth in Part 20. These limits are based on radiation protection guides recommended by the Federal Radiation Council and approved by the President; the recommendations of the National Council on Radiation Protection and Measurements and the International Commission on Radiological Protection.

The FRC numerical guidance applies to total radiation exposures from all sources, except medical procedures and natural background. It is expected that no one source shall contribute a disproportionate share of the total exposure. The FRC added to the numerical guidance on maximum limits the further guidance that "every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable." Similar statements are also included in NCRP and ICRP recommendations.

The Part 20 limits are designed to assure that exposures to the public from all AEC licensed activities that may be sources of environmental contamination are well within FRC radiation protection guides. This is accomplished by limiting concentrations and/or quantities of radioactivity permitted in air and water effluents at their source prior to release from a restricted area into the environment.

The proposed amendments, announced on March 27, would not modify the limits on radiation exposure, or on concentrations of radioactivity in effluents set forth in Part 20. These upper limits are now and will continue to be based on the recommendations of the FRC, as approved by the President.

The proposed amendment to Part 20 would express in the regulation the intent that consistent with FRC guidance all AEC licenses should make every reasonable effort to maintain radiation exposures and releases of radioactive materials in effluents to unrestricted areas as far below the limits specified in the regulation as practicable.

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[1] Deputy Director, Division of Radiation Protection Standards, U.S. Atomic Energy Commission.

This general principle of keeping exposures to radiation as far below limits as practicable has been a central one in the field of radiation protection and the nuclear industry for many years. Experience has shown that licensees have generally kept exposures to radiation and releases of radioactivity in effluents to levels well below the upper limits.

The proposed amendments to Part 50, the regulation which establishes design criteria and operating requirements for nuclear power plants, are intended to give appropriate regulatory effect, with respect to radioactivity in effluents from light water cooled power reactors, to the guidance of the FRC that radiation doses should be kept as low as practicable.

Experience with licensed light water cooled power reactors to date shows that radioactivity in water and air effluents has generally been kept at less than a few percent of the limits specified in Part 20. We believe that with the use of advances in reactor and waste treatment technology, further reduction of levels of radioactivity in effluents releases can be achieved.

The proposed amendments to Part 50 would assist in achieving this objective by requiring that an application for a permit to construct a light water cooled power reactor include a description of the equipment to be installed to maintain control over radioactive materials in effluents during normal reactor operations, including expected operational occurrences.

In addition, in the case of an application filed on or after the effective date of the proposed amendments, the application would be required to identify the design objectives and the means to be employed for keeping levels of radioactive materials released in effluents as low as practicable. This would provide assurance that advances in waste treatment and handling technology are used in the design of nuclear power plants.

Each application for a permit to construct a light water cooled power reactor would also be required to include an estimate of curie quantities of radionuclides expected to be released annually to unrestricted areas in plant effluents produced during normal operations and a description of the provisions for packaging, storage and shipment off-site of solid wastes containing radioactive materials from treatment of gaseous and liquid effluents and from other sources.

Each application for an operating license would be required to include a description of procedures for the control of gaseous and liquid effluents and for the maintenance and use of equipment installed in radioactive waste systems.

The Commission would review the proposed design of the reactor, the waste treatment equipment, and the description of the operating procedures for maintenance and use of the equipment to determine whether the required design objectives of keeping levels of radioactivity in effluents as low as practicable would be met.

Each operating license for a light water cooled power reactor would include technical specifications that would:

1. Require adherence to operating procedures for control of effluents and for the maintenance and use of equipment installed in the waste treatment system; and

2. The submission of semiannual reports containing information on quantities of radioactive material released and other information which might be required to estimate exposures to the public from radioactivity released in effluents.

If quantities released during the reporting period are unusual for normal reactor operations, including expected operational occurrences, the licensee would be expected to cover this specifically in his report. This reporting requirement would be in addition to existing Part 20 provisions requiring more prompt reporting of incidents involving overexposures or the release of excessive levels of radioactivity.

On the basis of these reports and other information, the Commission may from time to time require the licensee to take such action as the Commission deems appropriate to reduce levels being released.

We believe, based on experience, that waste treatment and handling systems designed and operated in accordance with the proposed amendments will keep releases of radioactive materials in effluents from light water cooled power reactors at small fractions of the limits specified in Part 20 and in operating licenses.

However, the licensee is permitted flexibility of operation, compatible with health and safety, to assure that the public is provided a dependable source of power even under unusual operating conditions such as perhaps a higher failure of fuel than was anticipated which may temporarily result in releases higher than such small fractions but still well within the limits in Part 20 and the operating license. In using this operational flexibility, the licensee is expected to exert his best efforts to keep levels of radioactive material in effluents as low as practicable.

The design objectives in the proposed amendments are stated in rather general terms. We plan to consult with the nuclear power industry and other competent groups to determine the feasibility of developing more definite criteria for design objectives and means for keeping releases of radioactivity in effluents from light water cooled power reactors as low as practicable.

In connection with the reporting of data on the release of radioactivity to the environment, we are developing uniform reporting requirements that will be included as technical specifications. These requirements define the types of in-plant monitoring programs and the types of information that the licensee must submit, including information on isotopic ratios in effluents.

We have felt the need for some time, and I know that the Bureau of Radiological Health has, for a more orderly system for gathering, collating and publishing data on releases of radioactivity to the environment. This includes the data reported by licensees, the data which is generated by the State health groups in their environmental surveillance programs and also the data developed by the Bureau of Radiological Health and AEC in independent monitoring programs.

For several months, we have been discussing this with the Bureau of Radiological Health in an effort to get a coordinated effort in this area. One particular area of importance, we feel, is better data on the source term. We feel that with sufficient data on source term that one can minimize the amount of effort in the environment.

This doesn't mean you don't have to take any samples in the environment, but it will provide very valuable guidance on maximizing the effectiveness of the environmental monitoring program.

We are attempting to develop a program with the States whereby the AEC might enter into contracts with the State groups to develop data, independent data, both on- and off-site, on releases in liquid and gaseous effluents as an independent check. This would be in addition to data which is submitted by the licensee.

We feel that the licensee should have the primary responsibility for developing the data, but there should be adequate independent checks so that we can have complete confidence that we have adequate data.

We are discussing this pilot program with two or three States. We want to get some experience with it to see if we can develop an effective and a meaningful program with the States along this line.

Thank you, Mr. Chairman.

MR. HARWARD: Thank you very much, Les.

Do we have one or two quick questions?

Yes, Sherwood.

MR. DAVIES: Les, I couldn't forego the opportunity of at least asking you a question. In your proposed changes to 10 CFR 20 and 10 CFR 50, the words "practical" and "reasonable" need some interpretation. Might it be assumed that when the AEC issues the specs as part of the operating license that there will be determined at that time what the release rate limits will be--liquid waste or discharge up the stack.

MR. ROGERS: Yes. The operating limits will be determined at that time. The operating limits will not be the same as the design objectives. At the time the application is submitted after this amendment becomes effective, the applicant would have to define design objectives and the equipment he is going to install to meet those design objectives. The design objectives would be well below the Part 20 limits. But the operating limits and the design objectives will not be the same.

MR. CLARK: I have one question, but it relates in two areas. And I am making it very specific because I think it is a question that is very relevant to this Conference. The question regards classification of materials by the AEC.

The first part of the question is this: Recently, Senator Muskie received a report prepared in May 1966 by the National Academy of Sciences, the National Research Council Report of the Committee on Geologic Aspects of Radioactive Waste Disposal. The conclusions state, "that the current practices of disposing of intermediate and low level liquid waste and all manner of solid waste directly into the ground above or in the fresh water zones, although momentarily safe will lead in the long run to a serious fouling of man's environment."

This is in response to a study of one of many stations, including Idaho, where the AEC at its installation at Arco has a practice of disposing of radioactive waste only 300 feet above one of the largest underground aquifers in the world.

Why did the AEC classify this report and prevent the American people from learning of the severe problem involving the disposal of radioactive waste? Why did the AEC not distribute this and two supplemental reports until 1970, a 4-year lapse?

MR. ROGERS: You should direct that question to the AEC. I don't have the specific details that you are asking for. I am in the regulatory program. We have no responsibilities as related to the Commission-operated activity. So I am not familiar with the particular issue which you are raising. I am generally familiar with the fact that the report has been made by the NAS-NRC.

MR. CLARK: Thank you.

The second question relates to WASH 740, the theoretical possibilities and consequences of major accidents in large nuclear power plants. The AEC published WASH 740 in March 1957, if I am correct.

In 1965, in a speech before the American Nuclear Society, the Los Angeles Section, a representative of the Joint Committee on Atomic Energy, Mr. Hosmer of California, stated: "Many of you are familiar with WASH 740 theoretical possibilities and consequences of major accidents in large nuclear power plants otherwise known as the Brookhaven Report. It was published in March 1957, and reflected the then state of the art in nuclear safety. I am informed that the subject has been under recent study and a revised WASH 740 will soon be published."

That was February 17, 1965. Why has this report not been made available?

MR. ROGERS: I don't have the answer to your question on that.

MR. CLARK: Is the AEC deliberately engaging in the hiding of information from the American people?

Let me direct a question to Mr. Villforth, the Director of the Bureau of Radiological Health. Do you have a copy or are you aware of the publication of this? Are you using this in your national practices for radiological safety? Do you have the updated version of WASH 740 for use by the Bureau of Radiological Health?

MR. VILLFORTH: I am not aware of it. I am sure that if it is available, someone on the staff has a copy and has access to it.

MR. CLARK: Let me ask one last thing.

MR. HARWARD: Could you hold it following the session? Everything you are asking is very good, but the questions have nothing to do with the subject that the speaker has just been speaking to.

MR. CLARK: Is the subject of this Conference the safety of the American people or the semantics of the profession of radiological health?

MR. HARWARD: It deals with the radiological health involving nuclear power reactors.

MR. CLARK: Are my questions relevant or not?

MR. HARWARD: They are not relevant to the speaker that has just spoken. The subject to which he was directing his remarks has to do with the routine operation of nuclear power facilities and what AEC is doing to help inform the public.

MR. CLARK: Wasn't WASH 740 a document published by the AEC to help inform the public of the minimal properties of a reactor "disassembling" itself?

MR. HARWARD: I think it was related to the maximum possibility rather than the minimum possibility.

MR. CLARK: The minimal chance?

MR. HARWARD: I would like to hold your questions if you would until after the session. Mr. Rogers has to catch a plane, and we want to go on to the next speaker. If you will come forward after the meeting, we would be happy to discuss these with you.

MR. ROGERS: Just one point. There are copies of this notice of proposed rule-making available for any of you who don't have them. I think all of you do, but I will leave them here.

MR. HARWARD: Thanks very much, Les, for coming down and filling in here at the last minute.

The next speaker is one whom I had the pleasure of working with several years ago when we established one of our field studies of an operating nuclear power plant. Mr. Leroy Stratton of the Illinois Department of Health has been working with that department for several years in which they have had an operating reactor since 1962.

They also have several other reactors that are either being constructed or else proposed for that State. One of the areas that we in the Bureau of Radiological Health believe is extremely important for State health agencies to become involved in concerns the emergency planning relating to each individual nuclear facility in their State.

Mr. Stratton is going to speak to us today on emergency planning as it relates to the Illinois Health Department program.

EMERGENCY PLANS

Leroy E. Stratton[1]

Many of you have or will be contacted by the nuclear industry or others to commit yourselves formally and in written agreements to assume responsibility in case of a peacetime radiological incident. When the general public becomes involved, we as a health department must assume our responsibility. And as we all know, emergency activities are very common for health departments in all of our areas of health interest.

In the preparation of emergency plans, a State must take a penetrating look at its own capabilities. Once a State becomes involved in self-assessments, it becomes clear that the adequate preparation of emergency plans requires an array of equipment, written agreements, training and a serious reflection of future problems. The State of Illinois is now preparing such plans and has made these reflections of its own capabilities. Primary emphasis was placed on the utilization of personnel to perform supportive tasks which are consistent with those tasks that they perform during their regular duties.

Of prime consideration in the development of these plans has been:

1. Coordinating local, State and Federal agencies which may play a useful role during such an emergency.

2. The acquisition and maintaining of adequate equipment.

3. Providing trained personnel to man the radiological response team; and

4. The completion of a plan using a format acceptable to all interested agencies who may be involved.

The State of Illinois is continuing to prepare an emergency response plan to offer guidance during a radiation incident. Our first draft was in 1958. Illinois has two power reactors in operation, five under construction, a spent fuel reprocessing plant under construction, 300 hospitals, more than 11,000 dental and medical x-ray units, and more than 700 AEC licensees.

Presently, we are negotiating to become an Agreement State. With this number of radiation users and the inevitable increase of users, it is essential that the State be able to respond to a peacetime radiological incident which may affect the health and safety of the general public.

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[1] Chief, Bureau of Radiological Health, Illinois Department of Public Health.

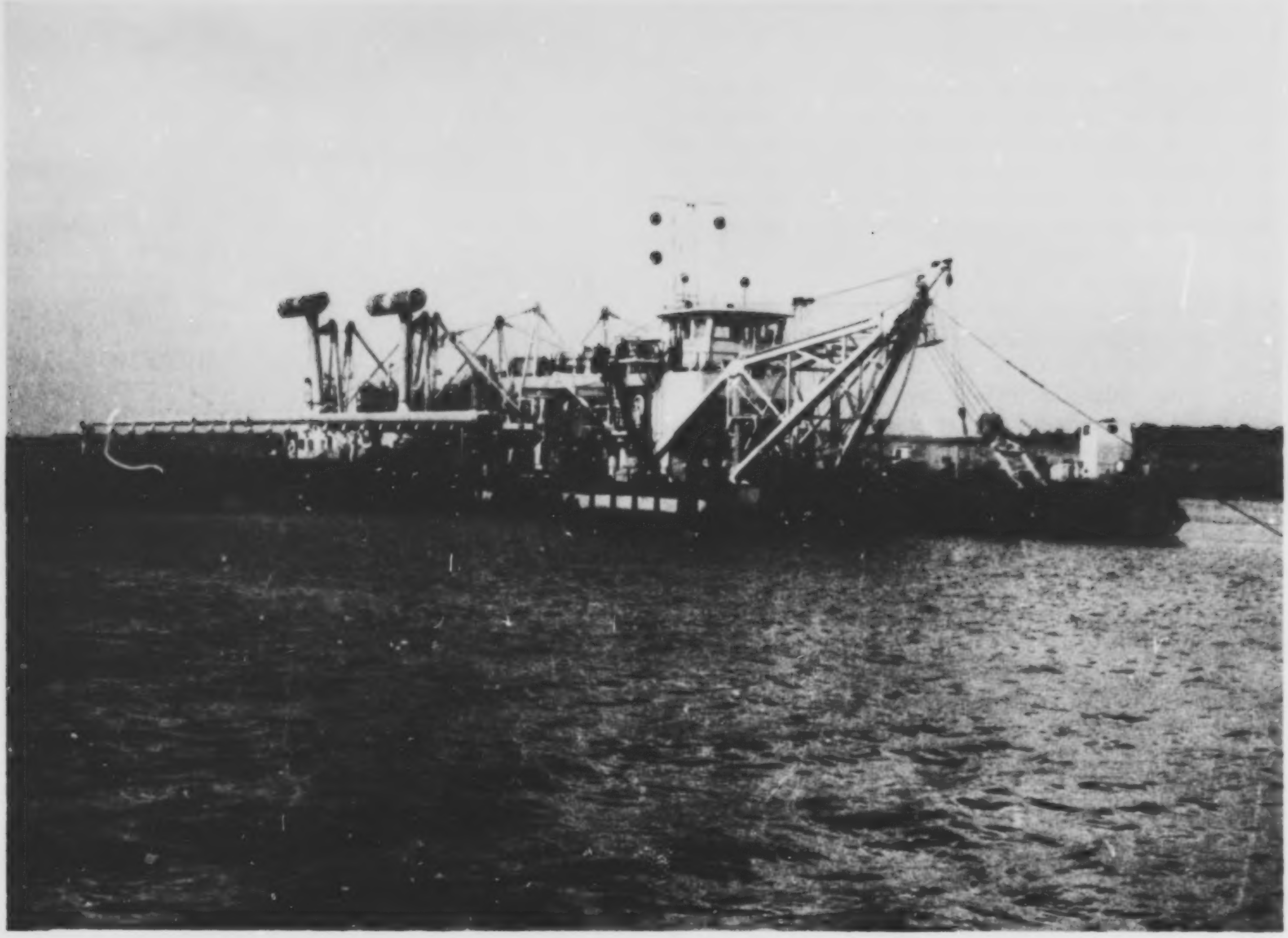

Figure 11. View of large scale spraying boom installed on a suction dredger.

Spraying Tests

The most promising agents were then tried out in small-scale spraying tests. A spraying boom with nozzles giving a flat curtain of spray was passed over a tank (1½ x 3½m) filled with sea water and oil (see Figures 6, 7 and 8). Sand/water slurries are thus spread over the floating oil and variables such as chemical concentration, slurry weight, speed and oil-layer thickness can be studied. It appeared that using a 1:1 weight ratio of sand/oil, a 5mm layer of heavy crude could be permanently sunk with an efficiency of 96%.

However, this method also has a limitation in that the viscosity of the oil that can be sunk successfully should not be too low, the lower limit probably lying around 200cS (at sea temperature). In this respect, the sand sinker method and the polypropylene scrubber complement each other very well.

Another item to which considerable attention was paid was the shape of the nozzles. Since scaling rules were not considered sufficiently reliable for this type of slurry flow, these tests had to be performed full scale, i.e. at pumping rates of $300m^3/hr$ and from heights of 4 to 5m (see Figures 9 and 10).

Large-Scale Test

At the same time as this development work was being carried out, preparations were also being made for a large-scale test on an actual dredger. To this end a boom was designed, carrying 20 nozzles at intervals of 1m (see Figure 11). The boom was mounted on one of the discharge pipes of a suction dredger, operating in the new harbor of Europort. This stationary-type dredger has no hopper for sand storage, but discharges the dredged slurry straight into open barges for disposal elsewhere. Facilities for injection of the wetting chemical were installed on the main pumping pipe.

Since it was obviously wise to avoid contamination of the harbor by oil, open barges were filled with water with a layer of oil on top. These barges could be towed at a predetermined speed under the stationary spraying boom, thus simulating the effect of a boom on a steaming dredger passing through an oil slick (see Figure 12).

During August of this year, a series of tests were run using this arrangement, and the method was demonstrated to representatives of interested authorities from the Netherlands, Great Britain, Belgium, France, Germany and the United States. It was shown that the scheme is workable and that the variables chosen were of the correct magni-

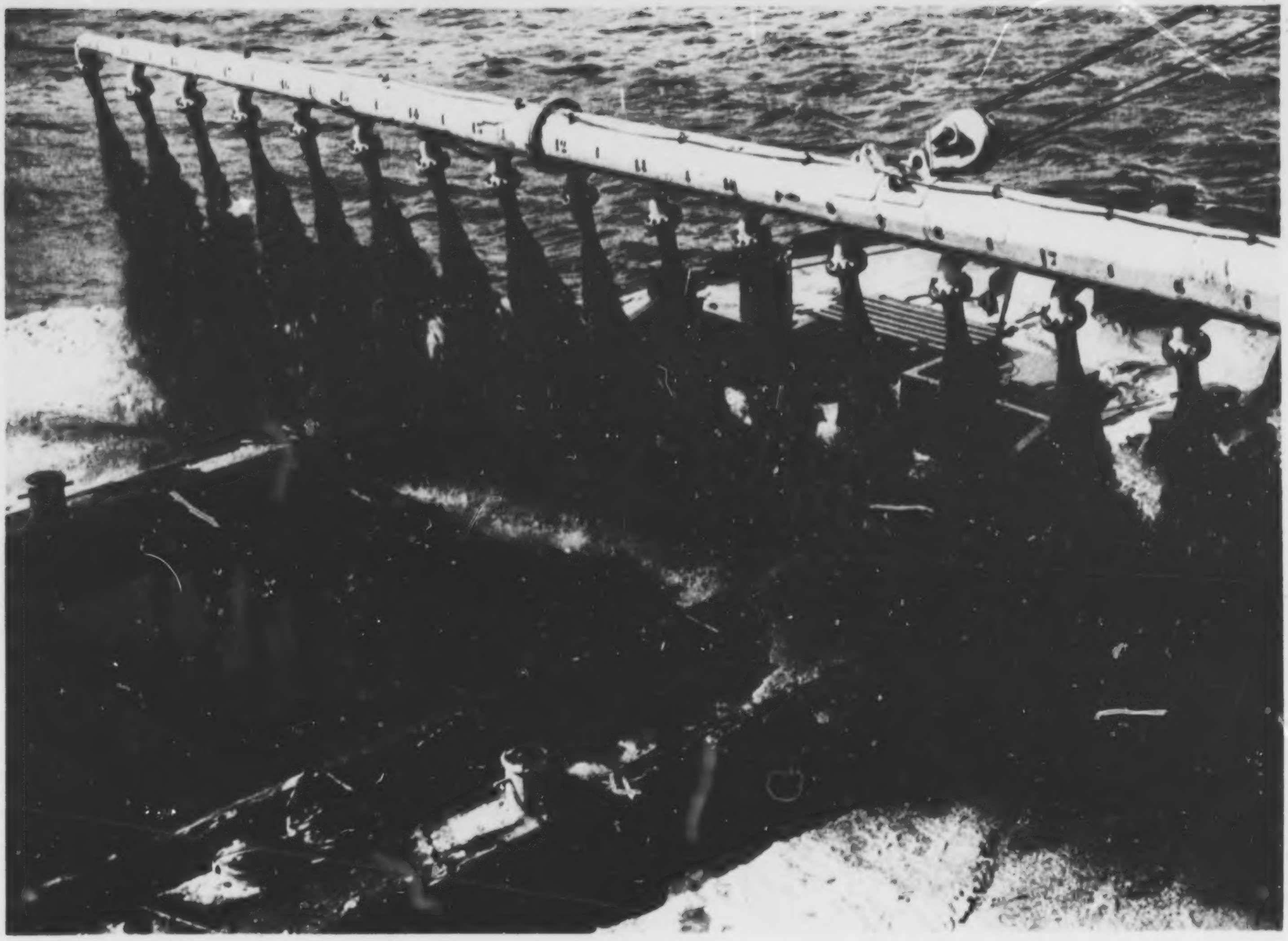

Figure 12. Barge with floating oil passing under the large scale spraying boom.

tude. A flow of slurry of $6000m^3/hr$ was applied over a width of 20m, thus discharging sand at the rate of 1500tons/hr. For a speed of 5 km/hr and an oil-layer thickness of 12mm, this amounts to a sand/oil ratio of 1.25:1.

One unforseen drawback was the fact that the dredged material from the bottom of the harbor to be deepened appeared to contain an unusual amount of fines (clay). It was known that the presence of clay would have an adverse effect on the efficiency of the performance, because this fine material absorbs the wetting agent. Notwithstanding, the presence of up to 20 per cent of clay in several of the runs, the percentage of oil sunk was still reasonable. A typical figure might be 75 per cent sunk at 10 per cent clay content.

A clear correlation was obtained between clay content and performance, as measured by the percentage of oil sunk (see Figure 13). This means that with sands containing less than 1 per cent clay, an efficiency of considerably more than 90 per cent can be expected, corroborating test results in the laboratory.

Full-Scale Trial

It is well known that on the bottom of the North Sea and the Channel the sand is very pure. This means that in an actual operation when sand is taken from the sea bottom, high efficiencies can be expected.

A trial of a suitable and deliberately laid oil slick at sea is planned in the very near future. If this trial proves successful, it is envisaged that contractual arrangements could be shortly concluded in order to render the Shell Sinker Method fully operational for emergency action in the North Sea and English Channel areas.

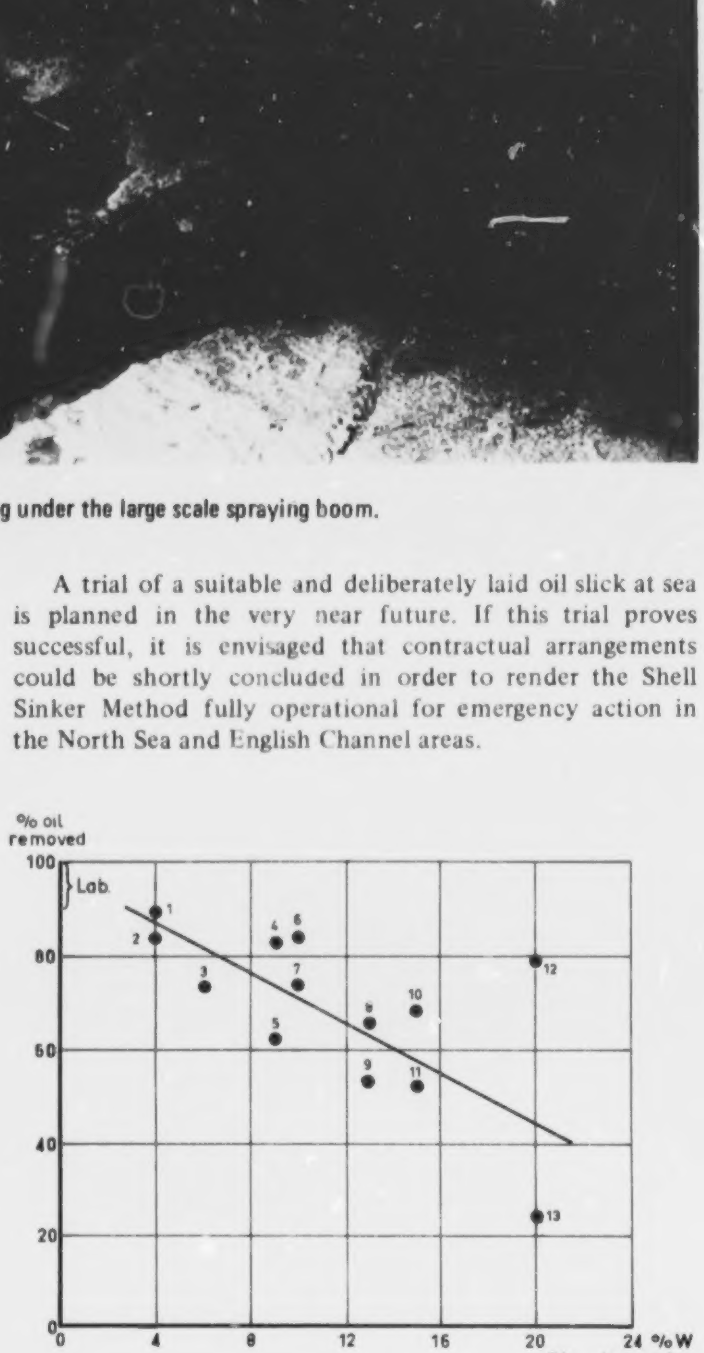

Figure 13. Graph showing the relationship of various sand/clay mixtures and per cent of oil removed by these mixtures.

Pollution Control At A Major Oil Spill

T.H. Gaines
Coordinator, Air and Water Conservation
Union Oil Company of California

Abstract

The eruption of crude oil from the ocean floor five and one-half miles offshore from Santa Barbara, California on January 28, 1969, created a substantial task of pollution control and property cleanup. In spite of all difficulties encountered, the beaches, harbors, houses, boats and shoreline have been restored, and in some cases, exceed their original beauty and cleanliness. The cleanup has been costly and time-consuming. More than $4,500,000 has been spent in the prevention of pollution and restoration of property and the environment.

On January 28, 1969, at about 11:00 a.m. during and following normal well drilling operations at Union Oil Company's Platform A (lease 402) in Federal waters off Santa Barbara, California, an oil leak occurred. Federal and State regulatory agencies were promptly notified and company executives and management personnel were alerted.

Observations made at 7:30 a.m. on January 29, in an over-flight of the area by helicopter, showed a major, violently agitated area about 800 feet east of Platform A. A brownish appearing mixture was erupting from the water surface, spreading in a circular configuration. The shade of the mixture darkened with distance from the source, taking on a more typical appearance of crude petroleum about three-quarters of a mile from the emission. Several small emissions were observable along a west to east line, with one small emission west of the platform. The densest area was about one-half mile in diameter and involved the platform structure. An oil slick approximately 25 square miles in area extended easterly from the platform. Patches of oil were breaking off from the main body in wind rows. These patches were tending toward the Santa Barbara, Montecito, Summerland and Carpinteria beaches.

Phase I—Efforts to Limit Pollution

The first pollution control objective was to disperse, with chemicals, the smaller oil patches headed for the beaches until such time as containment and recovery equipment could be marshalled to attack the main oil slick.

Simultaneously, an organization had to be established and manpower mobilized. In this respect, it must be noted that the assigned Union Oil Company Oil and Gas Division personnel had their hands full, working on stopping the oil source. Needed personnel, especially supervisors, were obtained from other divisions of the company, particularly from the Refining Department.

Because of widely circulated reports of damage resulting from the dispersants used by the British in their battle with the oil from the *Torrey Canyon* wreck, many public water pollution control agencies either objected to, or forbid their use.

In order that all misunderstanding could be avoided, request was made and permission received at 3:30 p.m. on January 29 from Washington, D. C. via the Regional Office of the Federal Water Pollution Control Administration, to use chemical dispersants. Use was to be in accordance with Department of the Interior policy on the use of chemicals to treat floating oils as follows:

1. Chemicals should not be used to emulsify, disperse, solubilize, or precipitate oil whenever the protection or preservation of the following are of concern: (a) fresh water supply sources, (b) major shellfish or fin fish nurseries, harvesting grounds or passage areas, (c) beaches.

Such chemicals should only be used in those surface water areas and under those circumstances where preser-

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vation and protection of water related natural resources is judged not to be the highest priority, or where a choice as to resource preservation may make the use of such materials a necessary alternative.

2. Examples of areas and circumstances where the use of such chemicals might be acceptable are:
   a. Where fire or safety hazards are presented by the spill of a petroleum product;
   b. Where large numbers of waterfowl may perish because of the proximity of floating oil;
   c. Under certain conditions, as a "polishing" or final clean-up of light slicks of oil following mechanical removal of floating oils.
3. Chemicals that emulsify, disperse, solubilize or precipitate oil should be used only under the immediate supervision of the Federal Water Pollution Control Administration except where it is judged that fire or safety hazards require the immediate application of such chemicals.
4. When chemical compounds are used in connection with oil clean-up, only those compounds exhibiting minimum toxicity toward the aquatic flora and fauna should be used. The Federal Water Pollution Control Administration is now developing and will soon issue a standard procedure for determining the toxicity of such chemicals.
5. Materials which aid in the collection of floating oils such as sorbents, gellants and viscosity control additives are considered to be generally acceptable providing that these materials do not in themselves, or in combination with the oil, increase the pollution hazard.
6. Research and development to improve chemicals which emulsify, disperse, solubilize or precipitate oil is encouraged. Whenever it is demonstrated to the complete satisfaction of the Federal Water Pollution Control Administration that such a chemical, by itself and in combination with oil, is non-toxic, its use may be approved in the areas where the protection or preservation of a. fresh water supply sources, or b. major shellfish or fin fish nurseries, harvesting grounds or passage areas are a prime concern.

A work boat whose fire water pump had been adapted for applying chemical solutions was dispatched to Platform A to disperse the oil and gas now presenting a substantial fire hazard to the structure. A small supply of Guardian Chemical Company's Polycomplex A-11 was on hand and was used this first day.

Two crop dusting airplanes and a supply of Enjay Chemical Company's Corexit 7664 were hurriedly ordered and ready for use January 30. The decision to use Corexit 7664 was based on reports of its low toxicity to marine life and reports of its successful dispersion of oil from a large tanker spill. Some comparative bioassay data are shown in Table 1. The chemical company representatives were on the scene to supervise the use of the chemical and assist in the operation.

The dispersant was applied by the airplanes on January 30. Application was at a rate of 40 gallons/acre, using full concentration (40% active material).

No dispersants were used inside the one-mile limit at any time, except on the evening of February 4, when oil penetrated the Santa Barbara Marina.

Efficient application of the liquid dispersant was not good due to the problem of locating the oil patches from low-flying aircraft. The procedure was to locate a slick visible from an altitude of perhaps 1000 feet, then circle back and spray the slick from an altitude of about 50 feet. At best, only an approximate location for the chemical drop could be made.

On January 31, the application of dispersant was carried out by both airplane and boat. The two crop dusters worked on isolated slicks, migrating toward the beaches. A specially equipped spray boat worked on the shore side edge of the main slick and the original work boat, using a pump, hose and nozzle, dispersed the oil under and near the platform.

By the evening of January 31, an inventory of 125 drums of Corexit was on hand and an additional 120 drums in transit. A total of 147 drums (8085 gallons) had been used the first two days. Work was in progress to equip two additional boats for chemical application. Assignments for an all-out effort to disperse slicks, some within two miles of the beaches, were prepared the night of January 31 and early morning hours of February 1.

A survey of the Santa Barbara Channel at dawn February 1, revealed the oil slick thickly packed in approximately a one-mile isosceles triangle whose apex was Platform A. The slick thinned out in a southeasterly direction with a show of dense patches as far east as Rincon Point, approximately 15 miles away. A thin, grey film covered an area of about 150 square miles.

The aircraft were readied for takeoff and the spray boat dispatched to a point two and one-half miles offshore from Summerland, where a dense patch of oil had been located. At 8:30 a.m., the Regional Director of the Federal Water Pollution Control Administration requested cessation of all uses of chemical dispersants.

The Director was of the opinion that based on the manufacturer's claim of 50 gallons of oil dispersed per gallon of Corexit applied, 10,000 barrels of oil should have been dispersed. Since the Company estimated the emission at 500 barrels per day, obviously the dispersant was ineffective. This conclusion upon examination was not valid, since there was no way of determining the efficiency of application. The important question was the effect on the marine ecology due to the concentration of the dispersant in the water column. The concentration was variously estimated at less than one part per million. Nevertheless, all chemical use was discontinued, airplane orders were cancelled and boats programmed for spraying were diverted to other uses.

At 3:00 p.m., the Federal Water Pollution Control Administration (FWPCA) order was rescinded and permission was given to continue to protect the platform with dispersants and to use them on the leading shore edges of the slicks, in choppy water outside the one-mile limit. However, the main thrust of the chemical treatment has been blunted and although additional spray boats were later used, airplane application was not again attempted.

Concurrently with the chemical treatment, a program for containment and removal of the main slick was formulated. A reinforced inflated plastic boom had been recommended by the Union Oil Company Research Department. A 1500-foot boom to be delivered in 500-foot sections, one each on February 1, 2 and 3, was ordered. The boom had a cross section diameter of 20 inches and was equipped with a 30-inch skirt, weighted with sand.

A floating skimmer for pumping oil from the water surface was under construction. A boat equipped with pumps and piping was being readied for use with the skimmer.

It was planned to concentrate on large sections of the oil slick with the boom, and pick up the oil with the skimmer, using a work boat's water tank for storage. A modification of this system worked well later in the emergency.

Other work boats, harbor booms, a barge and pumping equipment were located and leased.

No significant beach involvement with oil had been observed or reported up to February 2, 1969. All marinas and harbors proximately threatened had been equipped with booms and staffed with boom watches. A wildfowl treatment center had been established and staffed at Carpinteria Beach State Park to clean and house birds, now being affected in substantial numbers.

By February 2, the wind rows of oil and oil patches were, in some sections, within one mile of the seashore. It had been observed that there was a natural current barrier along which sea grass, storm trash and other debris had collected. This natural barrier extended from Santa Barbara to Oxnard at varying distances from the shoreline. At places, oil was collecting along the barrier. It was decided to attempt to reinforce this natural barrier with straw along those sections approached by the oil slick.

Straw mulchers used by the California Division of Highways to protect fill areas from water erosion were located through the assistance of the California Disaster Committee and the California Highway Patrol. These machines capable of broadcasting eight to 10 tons of straw per hour were delivered and put in service, one each on February 3, 4 and 5. A straw supply was obtained through the Union Oil Company Purchasing Department, the owners of the mulchers and local suppliers. Shipments were received from as far as Arizona.

The first section of the plastic boom did not arrive until late February 2. Crews worked all night to inflate and assemble this section. By daylight February 3, it became apparent that the boom would not meet open sea requirements. The sand used for weighting the skirts, migrated and caused boom sections to jack-knife, leaving breaches in the boom. Fittings broke under tow and sea stresses. It was decided to build log-type booms as a substitute.

A supply of wooden pilings was located in Los Angeles and the Guy F. Atkinson Co. was hired to build two, two thousand foot long wooden booms. The pilings were connected with one-inch steel cables. A seven-eighths steel cable, extending the entire length of each boom, was installed for towing and anchoring.

By 7:00 p.m. February 3, crews, equipment and materials had been assembled at Santa Barbara. The booms were finished and ready for use 20 hours later.

The staging area, by this time, has been described by some Pacific service veterans as reminiscent of the drive and vigor of a landing operation. There was an extreme sense of urgency felt by all of the oil industry personnel and their contractors. Hours of work and energy expended, ended only when near exhaustion.

The oil containment and recovery plan called for the Coast Guard to supply five pontoons as platforms for pumping and oil skimming equipment attached at the apex of a triangle formed by the wooden booms. The Coast Guard was to provide the anchoring system and boom tending operation.

The booms were turned over to the Coast Guard the afternoon of February 4, as scheduled. Because of heavy seas, they were able to tow only one of the booms to the platform and it subsequently broke away, with one 900-foot fragment returned to Santa Barbara harbor that night by the Coast Guard. The second boom was beached by Union Oil Company contractors when the Coast Guard could not handle it at sea.

Two of the five pontoons broke away under tow and went ashore near the Biltmore Hotel. The remaining three were tied up at Stearns wharf, Santa Barbara. The forces of the sea were vividly demonstrated that night.

The storm of February 4 and 5 completely scattered the oil slick. Beaches were covered with oil. High tides and strong winds sprayed sea walls, cliffs and homes with oil. It was a dismal picture that greeted the viewer on February 6.

Because protection of the beaches was now redundant, use of chemical dispersants was discontinued on February 6, except for fire mitigation in the immediate vicinity of the platform and were not again used in any significant amounts until February 25.

On March 4, 1969 the U.S. Geological Survey extended the use of chemical dispersants outside of the immediate platform area (one mile circle) for dispersal of oil slicks. The following criteria promulgated in accordance with the National Multi-agency Pollution Contingency Plan.

1. Dispersants are not to be used unless all efforts possible are made to boom, contain, and *collect* such oil in the immediate vicinity of the platform.
2. All dispersant application is to be conducted under supervision of company staff and directed by competent company aerial surveillance. Government observers are to be allowed to observe and sample whenever they deem it necessary.
3. Only water soluble, non-aromatic, non-toxic (in dosages used), dispersants of proven effectiveness are to be used. No more than three different materials may be used at any one time. Application

of each of these materials shall be in distinctly different areas so that interaction between different materials shall be minimized.

4. Dosages shall be limited to no more than 5 ppm of the material when applied, calculated on the basis of mixing in a water column of three feet depth, multiplied by the width of the area of actual spraying, including the wake of the vessel, and multiplied by the distance traveled.
5. No material is to be dispensed except onto oil slick areas.
6. No application of chemicals is to be made in the waters of the State of California (within three miles of shore).
7. All application shall be in accordance with the best practices to obtain adequate mixing and dispersion.
8. A daily record of dispersant use is to be maintained by the company as to volume, product, vessel, and rate of use and the daily record furnished to the FWPCA.

No endorsement by the U.S. Government of the effectiveness of any product used, nor liability for its use is implied by this concurrence. The use by the company of dispersant materials shall be on the express condition that the U.S. Government, its officers, employees and agents, shall not be responsible for any damages or losses of whatsoever kind or nature, resulting from the company's use of the chemical dispersants, and the company shall agree to indemnify and hold harmless the United States, its officers, employees and agents for all such damages or losses.

To determine the dispersants that may meet the criteria of Item 3 above, toxicity should be measured by use of standard bioassay procedures, using marine organisms common to the area. Samples of the materials used shall be made available to FWPCA when requested.

This concurrence is under Paragraph 2b of the "Department of the Interior, Federal Water Pollution Control Administration Policy on the Use of Chemicals to Treat Floating Oils," July 5, 1968. A previous concurrence under Paragraph 2a of the Policy shall continue in effect at such times as there is a fire hazard in the platform area.

It is understood that this concurrence and the conditions thereof will be attached to and made a part thereof of any instructions issued by the United States Geological Survey to the Union Oil Company, with regard to the use of chemical dispersants pursuant to the present oil seepage in the Santa Barbara channel related to Outer Continental Shelf platform A.

This concurrence is subject to modification or withdrawal upon 24 hours written notice to the U. S. Geological Survey.

Phase II—Cleanup

The involvement of the beaches with oil presented a new set of problems. Absorption of the oil by some means to prevent penetration into the sand was considered to be the first priority. Again the straw mulchers were successfully used both from boats and directly on the beaches to broadcast straw. Removal of the oil soaked straw had to be expedited to prevent its burial by the littoral drift of the sand.

Open beaches and the Santa Barbara Marina received the first concentrated effort. Later, rocky areas and seawalls were cleaned. Limited accessibility in some areas slowed the restoration. The tremendous quantity of driftwood and debris deposited on the beaches and coastline added to the cleanup burden. Severe winter storms had loaded the beaches with trash. Santa Barbara was declared a disaster area by Governor Reagan not because of oil, but because of severe storm damage. Many sewerage treatment plants were damaged or destroyed, filling the nearshore ocean waters at Oxnard, Ventura, Lompoc, Pismo and Santa Maria with millions of gallons of raw sewage. It is estimated that over 30,000 tons of storm debris were cleaned up by the Union Oil Company at no cost to the public agencies.

Supplementary manpower was obtained from the California Department of Conservation. With shutoff of the oil source on February 7, beach cleanup was escalated. The labor force peaked at nearly 1,000 men and supervisors. (An organizational chart is shown in Table 2.)

The beach restoration was principally done with hand labor, raking up straw. In accessible areas on non-rocky beaches, graders, bulldozers and skip loaders augmented the hand labor. Under these circumstances, 50 men aided by four skip loaders, two bulldozers and ten trucks could clean one mile of beach, per eight-hour day.

Rocky beach, sea wall and breakwater cleaning with manual labor, hydroblasters, sandblasters and hot water was slow, arduous work.

One contractor, Bennett International Service, Inc., used a slurry of talc and napththa to dissolve the tarry oil which had dried out on the rocks. The napththa evaporated, leaving a hard crust of oil and talc. The crust was removed by water blasting at 4,000 psig., disintegrating it into a harmless brown dust.

A systems unit, comprising slurry mixing and spraying, a water blaster staffed with nine men, seven of whom were lancemen, averaged about 1,500 square feet per eight-hour day.

Full use of the beaches except for an occasional temporary recontamination was available by June 1, 1969. Seawalls and rocky areas were not finished until August 15.

On February 25, ocean floor seeps had become active to the extent that containment, retrieval and dispersal action was again necessary.

The results of controlled tests indicated that mechanical agitation was as effective as some chemicals in dispersing the type of oil encountered at Santa Barbara.

Even the most effective dispersant (Ara Chem, Inc.) needed effective agitation.

Therefore, two chemical spray boats augmented by as many as 10 power boats for mixing, succeeded in effectively dispersing the seep oil.

A mobile oil skimmer was built, using an original Union Oil Company Engineering Department design for oil retrieval, and put in service.

A unique system of containment was developed by Union Oil Company Oil and Gas Division personnel with cooperation from a fabrics supplier (Firestone Tire and Rubber Co., Coated Fabrics Division). Underwater hoods or tents were installed on the ocean floor to collect the seep oil and carry it through flexible connecting hoses to tanks on the platform. The devices cover some 40,000 square feet of ocean floor and are doing an effective containment job. The first two tents constructed were flat surfaces. Later ones which are 100 x 100 feet are shaped with a predetermined rise in the center giving a pyramidal shape. The tent center is held aloft off the ocean bottom with buoys allowing the gas and oil to migrate toward the tent apex to which the production hose is attached. The gas and oil reach the surface with sufficient pressure to lift the liquid to a tank on the lower level of the platform. The tents are securely lashed to a frame slightly larger than the tents' base dimension. The frame is constructed of 20-inch pipe, reinforced at the corners and equipped with sea-cock and air release valves in each leg. The entire structure is buoyant when the pipe frame is not flooded. If properly lashed, the tent and frame may be slowly towed.

Summary

There was a degree of success in all procedures used in the pollution control efforts.

The use of Corexit met with some success the first day or two of its use. Thin stringers of oil broke up those first days; no oil reached the beaches. However, as the character of the oil changed, neither Corexit 7664 nor Polycomplex A-11 was effective. Arachem Goldcrew dispersant properly applied and mixed, performed well on unweathered oil. Weathered oil could not be dispersed chemically or mechanically.

A qualitative test of the ability of Corexit 7664 and Polycomplex A-11 to disperse crude oil floating on sea water was made on February 9, 1969 near Platform A. Using sea water as the diluent, the dispersants were sprayed on a crude oil slick. The following observations were reported:

1. There appears to be no significant difference in the dispersion ability of Corexit and Polycomplex when Polycomplex is applied at approximately one-half the dosage rate of Corexit.
2. When either Corexit or Polycomplex was sprayed on a black crude slick and not mixed by the wake of a moving boat, very little dispersion of the floating crude occurred at the point of spray entry into the floating crude. There appeared to be a sharp reduction in surface tension. The floating crude oil pulled away from the point leaving a brownish wrinkled floating layer of thicker crude surrounding green water. Microscopic inspection of the brownish layer revealed water in oil emulsion.
3. When either Corexit or Polycomplex was sprayed on a black crude slick and mixed by the wake of the boat moving at 10 knots/hour, there appeared to be good dispersion along the boat's path for a width of 150 ft. Green water was evident in the wake with small patches of black crude spreading out into iridescent and gray films. The boat path remained opened in the slick. After one hour, a bucket sample of sea water from the opened path contained many 0.010" diameter and smaller spherical particles of black oil. Some of the larger particles of black oil floated to the surface in the bucket and broke into an iridescent film. Many of the smaller particles failed to rise to the surface of the sample after one hour of settling.
4. When the boat was run through the slick at 10 knots/hour with no application of dispersants, the slick was dispersed along the boat's path very similar to the runs with dispersants. The boat path remained open in the slick. The bucket sample of sea water from the open path appeared similar to those obtained in the dispersant runs. There were possibly a few more larger spheres of oil that settled to the surface and decayed into an iridescent film.
5. It was concluded that the dispersants tested were not significantly better than the mechanical mixing energy supplied by a boat's propellers when attempting to break up an oil slick in open sea.

The tests were conducted, utilizing the supply ship *Pike I* which is a flat bottom vessel of 130 ft. length, 30 ft. beam and twin screw with 1,300 h.p. All running tests were conducted at 10 knots/hour at an estimated 70% power setting.

The dispersants were applied by pumping 200 barrels/hour of sea water through a 1-1/2 inch pipe by 20 foot long nozzle spray boom mounted forward and two 1-1/2 inch fire nozzles mounted aft. The spray system gave a net 30 foot wide spray application on either side of the vessel. The dispersants were added into the suction of the sea water pump at the following rates (55 gal. bbl.):

Corexit 7664 @ 2-1/2 barrels/hour
Polycomplex A-11 @ 1 barrels/hour

A black crude oil slick of approximately 200 feet width and two mile plus length was utilized for the tests. Thickness of the oil in the slick was estimated to be approximately 1/16 inch thick at the center. The boat cut across the width of the slick during the test runs. Winds were slight at less than three knots/hour from 310 degree compass bearing. Ocean swells were slight (one foot) with no wind ripples.

An evaluation of the oil dispersal properties of Ara Chem Goldcrew dispersant was made on March 2, 1969. The investigator reported:

The system employed for applying the dispersant consisted of a sump pump taking sea water suction, and a second pump taking suction on barrels of the chemical, admixing it with the sea water and discharging the mix through two fire hoses equipped with 90 gpm nozzles at a pressure of 85 psi. The hoses were affixed on each side of the vessel just forward of mid-ship. Application was made by directing the nozzles straight down from the hull then whipping the nozzles, adjusted for a nearly straight stream of water, through an arc of 10 to 15 degrees perpendicular to the side of the hull. This resulted in a violent agitation of the water surface for a distance of about six to ten feet. The strength of the stream alone was sufficient to break up the continuity of the oil slick.

Additional agitation of the oil-chemical mix was provided by work boats plying at fairly high speeds across and through the sudsy wake left by the chemical. The suds resulting from application of the chemical are in themselves of little value. Little, if any, chemical action was noted in the foam line. For inner harbor work, esthetics would be better served if no suds were produced.

The chemical as it works, first turns the oil to a dark brownish color. This effect was particularly notable as the work boats plowed through the dispersant boat's wake. The black oil from their bow could be seen turning brown as the chemical-oil mix became agitated together. It is apparent that dispersion, regardless of chemical concentration, is slow and inadequate, unless proper agitation is provided. The volume of oil on the surface at the time the test was made and the combined boat and wave action made it essentially impossible to retrace the boat's course and determine if a clear swath had been established. Even so, the product was doing a good job of dispersing the oil.

Some rather crude hand tests were made using one quart Mason jars to further determine the chemical's effectiveness. By sampling the oil and the chemical mixture being applied, hand mixes were prepared and agitated by shaking. At concentrations of approximately four gallons of chemical per barrel of oil, it was noted that shaking did disperse the oil and that no oil clung to the sides of the jar. Upon standing, the oil re-agglomerated at the surface, but had lost its stickiness. Slight agitation, similar to wave action, would again disperse the oil throughout the jar. Results at such low concentrations would be slow, but with continued wave action would probably be effective.

Where lesser amounts of chemical were tried, some dispersion took place, but the oil came back together on standing and would not again disperse on shaking. A rather rapid conclusion was that a concentration in the area of ten gallons of chemical per barrel of oil would be the most economical and yet effective application of the Ara Chem Goldcrew dispersant.

Later tests on heavily weathered oil proved completely ineffective. Chemical was applied essentially full strength with the result that some iridescent film was released, which could only result in the oil becoming even more sticky and tarry.

No general conclusions should be drawn from the foregoing tests. The results obtained on other crudes under other circumstances could be entirely different. These results are presented only to show the methods used and complexities associated with controlling massive oil spills. Even the passage of time is important for the character of the oil changes and hence the method of control must also change.

A problem in both dispersing and skimming is locating the oil slicks. High-flying spotter planes can guide the boats by radio but detection of the slicks at deck or pilot house level is most difficult.

Both Polycomplex A-11 and Corexit 7664 were used in the Santa Barbara Harbor the night of February 4. Polycomplex A-11 was used to mitigate the fire hazard inside the harbor. Oil had poured through a breach in a section of an inflated boom which deflated when a Santa Barbara Harbor Department boat rammed it. Corexit was used outside the boom at the breakwater entrance and in the vicinity of Stearns wharf and the Underseas Garden aquarium. It is instructive in this respect that although about 1,000 gallons of Polycomplex A-11 and probably an equal volume of Corexit were used to eliminate the fire hazard, no adverse effect on the fish life in the Underseas aquarium was reported.

Booms used for harbor and marina protection were effective except in Santa Barbara. Double booming was used in most instances with straw used to absorb carry-through oil instrusion between the booms. A 500-foot section of the original inflated plastic boom was modified to include filling with plastic foam and with chain weighted skirts, performed well at the entrance to the Channel Islands Marina. No satisfactory offshore boom was found.

A "bubble barrier" installed at the Santa Barbara Marina did not come up to expectations, probably due to inadequate design.

Anchoring of booms offshore was never adequately demonstrated. It appears some sort of mobile thruster system is needed to properly position booms to meet varying current, wind and tide conditions if oil slicks are to be contained in the open sea.

Floating oil skimmers built during the emergency, work well in waves up to six feet and relatively heavy oil concentrations. Although a high percentage of water was pumped, gravity separation readily occurred in the receiving tanks. The oil finally discharged at onshore facilities was a 50% oil-water emulsion.

A catamaran, equipped with a rotating polyurethane drum and wringers (Welles Product Co.), did not find conditions suitable to its operation at Santa Barbara.

Industrial foam sheets were tested and found inadequate for oil pickup.

On Saturday, February 22, 1969, a series of tests were conducted to determine the feasibility of using Scott Industrial Foam to remove or control free oil contamination from the surface of the ocean.

The first tests were run to determine how much oil would be absorbed by foam as it floated freely on the surface of the ocean. The foam used for these tests was 24"x36"x4" samples of Scott Industrial Foam 10 PPI, 20 PPI, 30 PPI, and 60 PPI.

The various foams were put over the side of the boat and directly into an oil slick. They were allowed to remain in the oil for periods ranging from 5 to 30 minutes. The foam was then removed from the oil and examined to check oil absorption and penetration. The penetration was determined by cutting into the center of the 4 inch slabs of foam and observing same. Penetration was approximately 1/2 inch to 3/4 inch in all cases. The surface absorption was visually examined. After each test, an attempt was made to squeeze out the oil that had been absorbed by the foam.

Upon examination of this first test, it was decided that the 20 PPI foam worked best; however, it did not absorb enough oil to make its use for large oil spillage applications practical.

The second test was run on a 24"x36"x4" piece of 10 PPI foam. Weights were attached along one of the 36 inch dimension of the material. The foam was then suspended over the side of the boat from a long pole and emersed in the water so that approximately 12 inches protruded above the water. Lines were attached to the foam so that it could be held in an upright position while suspended at a right angle to the side of the boat.

The boat then proceeded at a slow speed, (approximately two or three knots) through the oil slick. As the foam was moved through the water, it was observed that the water was passing freely through the foam, while the oil remained on the upstream surface of the foam. The foam was then removed and examined. A large quantity of oil was found on the downstream side of the foam. This test indicated that the 10 PPI foam could be efficiently used in the control, or pickup of oil from the surface of water.

The foam could be used to prevent oil from moving from one place to another, or to move the oil from one place to another, or to actually pick up small quantities of oil from the surface of the water.

It is believed the absorption tests were not practical. However, the boom type tests employing the 10 PPI were quite successful and might be developed.

On the beaches, natural clays and talc did not materially aid in oil removal. Straw was effective, but when deposited by the waves and tides in rocky crevices, was difficult to remove. Burning was tried for both oil and straw removal with no success.

The straw mulchers were excellent for a high rate of straw broadcasting both at sea and on the shore. No mechanical straw retrieval system was available or developed. Kelp cutters were considered but none was available. A purse seiner was reserved, but released, when no personnel liability insurance could be obtained.

Rocks, seawalls and the Santa Barbara breakwater were cleaned using warm water, steam, hydroblasting or sandblasting. As previously stated, a naphtha-talc slurry aided the cleaning process in one system.

Some experimenting was done with sinking agents without substantial success. On January 30, 3,000 pounds of equilibrium fluid catalytic cracking catalyst was spread by airplane on an isolated oil slick. The application was good but the slick and catalyst continued to float. Cement, bentonite, talc and diatomaceous earth were also tried at various times with little success.

TABLE 1–DISPERSANT BIOASSAY[1] RESULTS

Dispersant	24-Hour TL$_m$, ppm	96-Hour TL$_m$, ppm
Arachem Goldcrew	128	128
Corexit 7664	15900	7200
Crain OD-2*	125	118
Polycomplex A-11	225	134
Surfemul No.5+	350	350
Unico†	220	220

1. Standard Methods for the Examination of Water and Wastewater, Twelfth Edition (1965).

*Crain Industrial Products Co.
+3C Chemical Corp.
†Universal Supply Co.

A satisfactory method for application of finally divided substances was developed. An oil slick was sprayed with treated United Sierra talc, using a regular foamite fire fighting generator and a boat's salt water fire system. A 1-1/2 inch orifice nozzle and a system pressure of 50 psig were used. Talc could be sprayed fairly evenly on a spread of about 10 to 12 feet. An area of about 1,000 sq. feet was covered in 25 minutes with 500 pounds of talc.

From a nucleus of three supervisors on January 30, 1969, the organization expanded to 36 foremen and supervisors directing the operations (Table 2). By February 11, 1,000 men had been recruited, 18,900 feet of booms were in place, 125 pieces of mechanical equipment, 54 boats of all types and 3,000 tons of straw were on hand or had been dispersed. (Appendix I). Security guards and traffic directors had been stationed. Daily planning and reporting was in effect. (Appendixes II & III). A radio transmitter-receiver had been installed in the headquarters office. Walkie-talkies were in use in the field. These radios were very valuable. Much time was lost in the first week due to lack of communications.

The disposal of mountains of storm debris along with oil-soaked straw and sand was a very serious problem. A tremendous quantity of wood, trash, leaves and kelp, deposited on the beaches and shores by severe winter storms, was oil-covered and had to be removed. Legal disposal sites were limited. Santa Barbara city officials did not permit the use of the city dump. The Santa Barbara county dump was inaccessible because of a road wash-out. Ventura and Oxnard sites were quickly overtaxed. Many loads were hauled to Fillmore, over 50 miles distant. The

TABLE 2–ORGANIZATIONAL CHART
Company Coordinator – Operations Manager

Sandyland Area	Beaches Harbors	Ventura Area	Planning	Boats, Sea Operations	Communications	Wildlife	Supplies Equip.	Nights
					Supervisors			
(1)	(20)	(3)	(1)	(1)	(3)	(1)	(2)	(2)

City and County of Ventura and the City of Carpinteria authorized burning on their beaches at certain locations which materially aided the cleanup there. (Appendix IV).

The insurance carriers arranged for the cleaning of some 1,000 boats and provided crews to clean private seaside homes and yards, which had been fouled by oil during high tides and storms.

There was at no time any shirking of responsibility by the Union Oil Company or its partners, Gulf, Mobil or Texaco, in restoration of the Santa Barbara-Ventura coastline to its original beauty and charm. The present cleanliness of the area stands as testimony of the ability and willingness of the members of the petroleum industry to fulfill both their legal and moral obligations at all times and under all conditions.

APPENDIX I–EQUIPMENT LIST

Boats

Name	Owner	For Use As
1. Coast Tide 76'	Tidewater Marine	Straw spreader
2. Sea Truck 65'	General Marine Transport	Straw spreader
3. Zelma 54'	General Marine Transport	Boom tending
4. Pike I 135'	WODECO	Spraying and Skimming
5. Pike II 30'	WODECO	Boom tending
6. Oil City 100'	Port Hueneme Ind. Serv.	Spraying
7. Trojan 100'	Pacific Towing	Spraying
8. Petrel		Tug
9. RS-23 135 x 45'	Crosby & Overton	Boom tending–Ventura
10. Mary K	Private fishing boat	
11. Mary K Skiff	Private fishing boat	
12. Genes Folly	Private fishing boat	
13. Pieface	Private fishing boat	
14. Bonanza	Private fishing boat	
15. Sea Mistress	Private fishing boat	
16. Six Pak	Private fishing boat	
17. Gaviota	Private fishing boat	
18. Skiffs (2)	Rental	

Booms

1. 6" Foam float with 6" skirt @ 1800' – Hutchison
2. 28" Inflated sea curtain – 30" curtain @ 1000' – Union Oil Co.
3. Log boom @ 2000' – Union Oil Co.
4. Union Oil Co. 1000' plastic boom from Marine Terminal
5. Union Oil Co. 4 x 4 wood boom – 200'
6. Crosby & Overton – 3100'
7. U.S. Navy – 900'
8. Log boom 2000' – due 2/5/69
9. Plastic boom – 500' – due 2/5/69

Heavy Cleaning Specialists

1. Crosby & Overton

Chemical Services

1. Enjay Chemical Co.

Chemicals

1. Corexit 7664	120 drums	Santa Barbara
	99 drums	Stanton
	80 drums	Stanton (due 2/5/69)
	72 drums	Oakland
	800 drums	Houston, Texas
	650 drums	Bayonne, N. J.
	400 drums	Misc. U.S. cities
	10 drums	Santa Barbara
2. Polycomplex A-11		

Aircraft

1. Durden Bros. – Fish spotting service (for positioning boats)
2. Rotor Aids – Observation and transportation

Miscellaneous Equipment

1. Baker tanks (2) mounted on barge RS-23
2. Haliburton pumps (2) 1 on Pike I–skimming; 1 on RS-23–skimming
3. Crawler Crane (5) Ton mounted on RS-23
4. Essick pump 6"
5. Welding machine (rental)
6. Pick-up truck (6) (rental)
7. Food stores for U. S. Navy YO-223
8. 5000 lb. anchor–General Marine Transport
9. 1000 lb. anchor (2)–General Marine Transport
10. 250 lb. Danforth anchors (2)–Ocean Science and Eng.
11. 200 lb. Danforth anchors (3)–Ocean Science and Eng.
12. 150 lb. Danforth anchors (3)–Ocean Science and Eng.
13. 60 lb. Danforth anchors (6)–Ocean Science and Eng.
14. Round buoys 35" (3)–Ocean Science and Eng.
15. Round buoys 72" (3)–General Marine Transport
16. Can buoys 24" dia.x 30" (6)–Ocean Science and Eng.
17. Polyform buoys 30" dia. (4))–Ocean Science and Eng.
18. Polyform buoys 18" dia. (2)–Ocean Science and Eng.
19. Polyform buoys plugs (6)–Ocean Science and Eng.
20. Galv. chain 1/2" (343')
21. Wire rope–misc. sizes–10,000'
22. Shackles–misc. sizes–(100 est.)
23. Cable clamps–misc. sizes (2,000 est.)
24. Shovels (200)
25. Rakes (180)
26. Nylon line 1-1/4" (400')
27. Manilla line–misc.
28. Snow shovels (100)
29. Pitch forks (150)
30. Fibre drums (1000)
31. Buckets, 5 gal. (100)
32. Fertilizer spreaders (for talc)
33. Hand cleaner (100 gal.)
34. Push brooms (100)
35. Straw (100 tons/day)
36. Mulch spreaders (3)–boat mounted
37. Flat bed truck, 3 ton (3)–Crosby & Overton
38. Talc (3 tons)
39. Ekoperl (600 bags)–due 2/5/69

APPENDIX II - PROGRESS REPORT (DATE)

Santa Barbara Area - Beaches and Harbor

Gaviota - Stack and burn at Bulito, burn debris at Augustine. Van Construction - 23 men (2) loaders, (1) grader.

Goleta Park - Stack and burn debris. Hutchison - 11 men.

UCSB - Stack and burn debris, haul to Tajiguas dump. Hutchison - 8 men, (1) loader, (1) grader, (1) dozer, (7) trucks, (42) loads.

Miramar - Clean beach and haul debris. Crosby & Overton - 18 men. (2) loaders, (11) trucks, (49) loads.

Bonnymede - Wash rocks, stack debris. Crosby & Overton - 10 men.

Padaro Lane - Wash rocks, haul debris. Crosby & Overton - 13 men. Haul (6) loads.

Summerland - Stack and burn debris. Crosby & Overton - 6 men.

Rincon Point - Stack and burn debris. Crosby & Overton - 15 men. (2) loaders.

Harbor - Sandblast rocks at Undersea Gardens, hydroblast seawall, clean boat slips and walkways. Hutchison - 15 men. Crosby & Overton - 3 men. (2) hydroblasters, (2) punts, (1) skiff, (1) sandblaster.

Stearns Wharf - Crosby & Overton - 3 men.

Santa Barbara Area - Contractors and Equipment

34 men - Hutchison & Sons
62 men - Crosby & Overton
23 men - Van Construction
5 - guards
18 - dump trucks
97 - loads hauled
3 - graders

6 - loaders
1 - dozer
2 - hydroblast
1 - sandblast
0 - steam cleaner
1 - burner

Supplies and Material

Diesel - 966 gal. Gasoline - 105 gal. Solvent - 55 gal.

Boat and Sea Operations

Winn - Oil skimming
Judy 10 - Work with Winn
Seatender - Drilling operation
Mallard - Drilling crew change
Packer - Construction operation
Swallow - Construction crew change
Mary K. Skiff - Maintain boom in harbor

Chemicals

55 gal. sprayed at Platform A. Total to date from 2/26/69, 426.5 bbls.. 1 bbl. = 55 gal.

Ventura Area - Beaches and Harbor

Channel Islands - No oil in harbor - boom open. 7 men days - 6 men nights.

Port Hueneme - No oil in harbor - boom open. 2 men days - 4 men nights.

Point Mugu - No oil in harbor - boom open. 4 men days - 4 men nights.

Hollywood - Rake, stack and haul debris. Van Construction - 15 men. (3) loaders, (6) dumps.

Silverstrand - Rake, stack and haul debris. Van Construction - 14 men. (1) loader, (4) dumps.

Emma Wood, Hobson, Sea Cliff Arco areas - Steam clean seawall, haul debris. Allied Construction - 20 men, (1) crane, (3) loaders, (6) dumps, (2) steam cleaners.

Burn area - (1) D8 dozer, (1) fuel truck, (1) water truck

Guards - 6 men hay yard, 6 men burn area

APPENDIX III - PROGRESS REPORT (DATE)

Beaches and Harbors

A sand dike was constructed across the upper end of the beach lagoon adjacent to the bird sanctuary on East Beach. After diking, the slough was drained and cleaned. This was done at request of the City Park Department.

At Carpinteria State Beach, 150 inmates were used in cleaning beach and stockpiling. Debris burning continued.

Crosby-Overton forces were employed at oil wells near Summerland cleaning beach and stockpiling. Beach cleaning and stockpiling continued at Serena and Sandyland areas. Crosby-Overton employees were used at these locations.

Sixty inmates were used at the main Santa Barbara beach, raking and stockpiling. This beach has been worked, using Cat driven hayblowers as well as hay blown by Pike I. This beach is again in good shape.

Two different types of commercially available powered hay rakes were tried on this beach with no success.

Equipment used entailed: 6 small trucks, 11 loaders and one low bed truck.

Ventura Area

Ventura harbor remains clear of oil. Plans have been finalized for the following activity on 2/18:

Construction of a mounded buffer along the upper portion of Mandalay Beach.

Seventy-six conservation crewmen on Ventura beach proper to clean and stockpile. Burning will be started on 2/19.

Approximately 20 persons from Allied Construction Co. to clean beaches and steam clean sea walls at Seacliff in the Rincon Beach area.

Channel Islands - boom across harbor has been reset to provide a gate for easier passage of ships. Harbor remains clear of oil.

Port Hueneme - harbor remains clear of oil. Boom is open between 6 a.m. and 7 p.m. and is closed at night.

Point Mugu - remains clear of oil. Little activity in this area.

Planning

Ventura area clean-up was planned. Several hours were spent with THUMS personnel on explaining various types of booms. The beach area from Santa Maria south will be surveyed early on 2/18.

Boats and Sea Operations

Approximately 30 tons of straw were sprayed from the *Pike I* along the southern Ventura area, Santa Barbara Harbor area and about five miles outside of Santa Barbara. Hay was reloaded at Sterns Wharf and on the *Pike I* for continued spraying on 2/18.

Communications

Manager of Undersea Gardens was approached in regard to his water intake. Found that he's pumping from within the inner harbor area instead of from the outer harbor. He has had no problems with water quality. They are very appreciative of Union Oil efforts.

Cleaned all material from Navy pier in compliance with Harbor master's request.

Arranged for steam cleaning of dredge and first walkway of Marina I on 2/18. Have had some complaints of slippery conditions on this particular walkway.

Rigged skiff with clean hose and water pumper to start flushing of oil from individual boat slips in the inner harbor.

Installed mounted radio in truck P-104 and issued truck to Goyette to improve communications from the outlying areas of work. Will install two more radios in P-104 to further improve outlying communications.

Wildlife

Latest count: 4 p.m. - 2/16 - 1,146 treated; 311 recuperating; 141 DOA; 835 died after treatment.

This unit will probably be held at one or two men in case activity should increase. The recuperating birds are being transferred on 2/18 to the Child's Zoo.

Supplies - Equipment

Two deck scrub brushes; eight - 5 yd. loads 1-½" rock; five bundles rags; one case hand cleaner.

Nights

Maintained air curtain and boom surveillance.

An accident occurred during the night when a ship struck the floating air curtain being installed. Extent of damage unknown at this time.

APPENDIX IV - SANTA BARBARA CLEAN-UP OPERATION

Date	Loads Hauled	Dump Trucks
2/10		54
2/11	400	
2/13		6
2/15	23	
2/16		2
2/19		2
2/20		6
2/21	90	13
2/25	19	
2/26	80	20
2/27	138	30
2/28		4
Total Feb.	750	137
3/1		21
3/2	179	24
3/3	104	26
3/4	183	36
3/8	130	29
3/10	94	32
3/11	106	35
3/12	91	36
3/13	53	37
3/14	49	14
3/17	70	32
3/18	86	30
3/19	97	18
3/20	57	19
3/21	43	10
3/24	80	20
3/25	87	22
3/26	84	22
3/27	144	21
3/28	192	22
3/31	153	23
Total Mar.	2082	529
4/1	176	23
4/2	157	23
4/3	85	25
4/4	96	20
4/7	97	21
4/8	86	29
4/9	140	21
4/10	152	22
4/11	166	21
4/14	221	27
4/15	201	25
4/16	147	23
4/17	299	24
4/18	272	21
4/21	59	22
4/22	106	20
4/23	159	24
4/24	241	29
4/25	240	24
4/28	240	28
4/29	384	28
4/30	329	29
Total Apr.	4053	529
5/1	391	57
5/5	132	23
5/6	196	22
5/7	258	25
5/8	220	24
5/9	266	21
5/12	241	24
5/13	157	24
5/14	145	24
5/15	189	25
5/19	208	26
5/20	187	24
5/21	104	24
5/22	55	13
5/23	53	9
5/26	25	10
5/27	31	7
5/28	32	10
5/29	51	7
Total May	2941	399

FATE AND BEHAVIOR OF OIL ON WATER

Wednesday, December 17, 9:00 a.m.

Chairman: Dr. C.M. Tarzwell
Director, National Marine Water Quality Laboratory
Federal Water Pollution Control Administration

Co-Chairman: H.A. Bernard
Chief, Agriculture and Marine Pollution
Federal Water Pollution Control Administration

Identification Of Oil Spills:

Comparison Of Several Methods

J. Horowitz, G.D. Gumtz
R.G. Nemchin, T.P. Meloy
Melpar, An American Standard Company
Falls Church, Va.

Abstract

Based only on analysis of oil slicks, several methods of identifying the source of oil pollution are critically examined. These methods are grouped into two categories: passive tagging and active tagging. Passive tagging assumes that oils are so chemically diverse that their contents constitute a stable chemical fingerprint that can be unequivocally disclosed in the laboratory. Active tagging requires that an inexpensive, coded material be added to oil; this material must be chemically and physically stable in both oil and oil slicks; it must also be readily identifiable by available analytical techniques.

We have examined three methods of passive tagging (trace metals, sulfur-isotope ratios, and paper chromatography) and three methods of active tagging (halogenated polycyclic aromatics, organometallics, and coded microspheroids). Passive tags cannot be recommended because the passive tags are quite likely to mingle, to evaporate, to be dissolved, or to be oxidized; even if these processes do not occur, they can create formidable forensic problems for the prosecution and telling counter-arguments for the defense. Since active tags are designed to be stable and identifiable, they are made for the job; we have found promise and merit (though unequal) in the three types of active tags we reviewed.

General

According to the U. S. Coast Guard, there were 714 major spills in U. S. waters in 1968; in 1966 there were 371. These Coast Guard reports do not tell the whole story, for many oil spills are never reported to them. According to various official estimates, the true figure is more probably several thousand than several hundred. The problem of oil pollution is patently serious, and grows more serious with time. One of the great problems in combatting oil pollution is to identify the pollutor: oil pollution is illegal under at least six statutes of the U. S. Code.

While small amounts of oil pollution can come from thousands of sources, a great deal of oil pollution apparently comes from a few types of sources: tankers, offshore wells, storage tanks, and pipelines. Waterborne sources account for over half the pollution. While the problem is large, it is not infinite. There are 14,000 offshore wells, and 2,000 tankers making about 10,000 calls a year on U. S. ports. And only 400 of these fly the U. S. flag. The largest potential sources of pollution are few in number. The problem is: how to legally trace pollution to them, cheaply and unambiguously?

The most direct approach to tracing pollution is to compare the slick with the oil carried by the suspect source. This approach assumes that the slick will not differ significantly from the true source, and this assumption is justified if the word "significantly" is loosely construed. Everyone familiar with oil pollution knows about the weathering of slicks, and few would argue that the "chocolate mousse" variety of oil emulsion is significantly similar to any commercial petroleum product. The real problem is: how much weathering makes a slick unidentifiable? We shall presently return to this question.

Weathering: Chemical and Microbial

Oil is no simple compound or mixture of compounds. Crude and fuel oils show enormous variation in chemical content, both qualitatively and quantitatively. Naturally, variations in chemical makeup are accompanied by variations in physical properties. Perhaps the most important event in the history of an oil slick is the evaporation of the light fractions.

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While the rate of evaporation will be influenced by many variables, after several days at sea the slick will consist almost entirely of compounds whose boiling point is above 370°C (approximately 700°F),[1] viz compounds containing at least 20 carbon atoms, and probably of complex chemical structure. When oil is spilled on calm water, it rapidly spreads to a film about 2 cm thick. Although many variables affect its subsequent thinning, its final thickness will be 10-100 microns on pure water, but approximately 1mm on heavily contaminated water.[2] Thin films offer a larger surface (and hence, are more easily acted upon by the environment) than thick films.

While evaporation undoubtedly accounts for most of the volumetric loss in the slick, solution in sea water may also play a significant role. R. A. Dean[1] has argued that, while the lightest hydrocarbons have finite solubilities in water some heavier petroleum constituents, while undoubtedly less soluble, may still go into solution, for we are considering huge volumes of sea water. Dean has contended that if we assume a solubility on the order of one part per million, the whole cargo of the *Torrey Canyon* could have been dissolved in a patch of sea 20 miles square and 500 feet deep. In this connection, the presence of surfactants in natural crudes (surfactants such as porphyrins and metalloporphyrins) assumes a new significance. Moreover, trace metals in petroleum are often in water-soluble form, or become water-soluble as the slick weathers.

While the slick is spreading, evaporating, and being leached of its water-soluable components, other processes act upon the residue: catalytic autoxidation, photochemical oxidation, polymerization, and microbial oxidation. While we all acknowledge the fact that oil changes its character because of oxidation, solar radiation, and microbial action, we have little information about the specific operant mechanisms, reaction times, and reaction products.

The unsaturated, alkyl-aromatic, and alicyclic hydrocarbons in petroleum are probably oxidized to acids via peroxide, hydroperoxide, alcohol, and ketone intermediates.[3] In spite of the absorption of the shorter wavelengths of the sun's rays by the atmosphere–which reduces the ultraviolet light (UV) of less than 4000 Å to no more than 5 per cent of the total–there remains enough energy in the residual radiation to break a variety of chemical bonds;[4] in general, aromatic hydrocarbons are more stable than aliphatic hydrocarbons to UV and visible radiation. Ellis & Wells[5] have reported that solar UV causes oils to become colored and gummy in the presence of oxygen, and that the rate of gum formation triples for every 20°F rise in temperature. Wolsky & Chapman[6] have shown that UV caused porphyrins to disintegrate rapidly in the presence of oxygen. Oil slicks are also attacked by oxidizing microflora, which are common in both fresh and salt water.[7]

While many of the compounds in petroleum are undoubtedly metabolized, the metabolic pathways for large and complex hydrocarbons are not well established,[8] and the kinetics of oxidation (even for the smaller hydrocarbons) seem to be rather slow. It is well to bear in mind, however, that the species distribution of saprophytic microorganisms varies widely with latitude, and that diversified enzymatic activity is much more common in cold-water than in warm-water bacteria.[9] The question of microbial oxidation and assimilation of petroleum compounds is further complicated by the anomalous phenomena of cooxidation and oxidation of nonassimilable substrates, which have been reviewed by McKenna & Kallio.[10]

Passive Tagging

We have already raised the question of how much weathering makes an oil slick unidentifiable, but cannot answer it apart from a critical analysis of methods of identification. There are two general approaches to identification, which are sometimes called active tagging and passive tagging. Passive tagging is a convenient circumlocution for no tagging at all: nothing is added to the oil; the slick itself must provide all the evidence for its own identification.

Active tagging involves adding some known and readily identifiable material to the oil. The added material must satisfy several criteria: it must be soluble or dispersible in oil and insoluable and nondispersible in water; it must be easily detectable in extreme dilution; it must be chemically and physically stable in both spilled and unspilled oil; and it must not interfere with the commercial uses of petroleum. One additional criterion: it must not be too expensive. Two figures of speech are helpful in distinguishing active tagging from passive tagging: Passive tagging amounts to a "fingerprint," and active tagging amounts to a chemical or physical "license plate."

Heavy Hydrocarbons

Let us consider passive tagging first. We have seen that when oil is spilled, it may be irradiated; mixed with complicated aqueous solutions (sea water, polluted fresh water, or brackish swamp water); exposed to oxygen and air pollutants; and intimately associated with a variety of aquatic microbes; depending on local conditions, it may have been partially evaporated, emulsified, photolyzed, autoxidized, polymerized, enzymatically oxidized, and may have undergone ionic exchange.

What part of the fingerprint can be stable to all these conditions? Heavy and highly branched alkanes are excellent candidates; so are the heavy and complex hydrocarbons of mixed structure that are common in lubricating oil. However, the heavy branched alkanes are generally exceedingly rare in oil, because the concentration of branched-chain paraffins in crude oil is a rapidly decelerating function of molecular weight.[11] The mixed-structure hydrocarbons common in lubricating oils permit an almost infinite number of structures, and the likelihood of positively identifying any one of them becomes vanishingly small.[12] After all, even though several hundred compounds have been identified in crude oil, the identified compounds "probably account for well under 50 per cent of the constituents of a crude petroleum."[12] It should be apparent that the hydrocarbons in slicks of crude and heavy oils will contain an even higher percentage of unidentified structures. One must therefore conclude that although heavy, complex hydrocarbons are likely to be stable constituents of oil slicks, they will not serve as passive tags because they are exceedingly rare, exceedingly difficult to identify, or both.

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[1] Superior numbers refer to literature references at conclusion of text.

Trace Metals

What other constituents of oil might be used as a fingerprint? Trace metals (especially vanadium and nickel) and isotopic ratios have been suggested, and these will be critically reviewed next.

Many inorganics have been reported in petroleum ash; we had no difficulty finding reports of 37 inorganics, and the list could no doubt be extended. Many of these elements are rarely found, others are rarely found in high concentrations; only a few are frequently found in petroleum ash in concentrations above 0.1%, and of these few, special importance attaches to vanadium and nickel.

These two metals are important because of the problems they cause industry. Like most elements of the first transition series, both are dehydrogenation catalysts (nickel is about 10 times more potent that vanadium), and both are commonly found in petroleum as volatile compounds. For this reason, they are often found in distillate fractions, their concentration increasing with the depth of the cut. Some of these volatile organometallic compounds alter the selectivity of cracking catalysts, increasing the formation of coke and hydrogen and decreasing the yield of gasoline. Non-volatile vanadium, which concentrates in the residuum from which heavy fuel oil is produced, is extremely corrosive to fire-clay bricks used in furnaces; the vanadium oxides form low-melting eutectics with clay, producing hard, glassy slags that are extremely difficult to remove.[13,14]

Both vanadium and nickel are commonly found in petroleum as compounds of widely varying molecular weight.[15] Often, these compounds are water-soluble inorganics.[16] Of the organic compounds, special importance attaches to the nickel and vanadyl metalloporphyrins because these compounds are rather stable constituents of petroleum and have great geochemical significance.[17] It is well to remember, however, that only a small fraction of nickel and vanadium in petroleum is usually found in porphyrins.

While vanadyl and nickel porphyrins are rather stable compounds, they are also interfacially active and tend to concentrate at hydrocarbon-water interfaces. In light of this property, several workers have used water sprays to extract metalloporphyrins from oil; this method is thoroughly established.[16] Wolsky & Chapman[6] have also shown that when porphyrins are irradiated by UV in the presence of oxygen, they are rapidly decomposed. Furthermore, while the metalloporphyrins in oil usually have reduced side chains, oxidizing conditions usually result in polycarboxylic porphyrin structures, which have a very marked affinity for water interfaces.[18] Indeed, Falk[19] has demonstrated an almost linear relationship between the number of carboxyl groups on a porphyrin and the porphyrin's mobility in a solvent system of lutidine and water.

In view of the fact that both the vanadium and the nickel in petroleum are often volatile and water-soluable, it is difficult to understand why they have been seriously recommended as passive tags. Nevertheless, they have been recommended off and on since 1955, if not before. Since all the recommended methods require sampling of oil slicks–which will have been partially evaporated, thereby concentrating the involatiles–it is pointless to compare the absolute metallic contents of the slick with that of the unspilled oil. Rather, the ratio of metals (in particular, the ratio of vanadium to nickel) must be assumed constant. This strikes us as a perilous assumption, since (in general) nickel compounds in petroleum are usually reported to be more volatile and more water-soluable than vanadium compounds. The arguments advanced for vanadium and nickel tags are quite often mistaken on matters of fact:

> Vanadium and nickel are held in the oils as coordinated complexes with porphyrins, and are not affected by contact with sea water. . .[20]

or from a more recent proposal:

> The method simply entails measuring the vanadium and nickel contents of the unknown oil pollutant. There is a very specific amount of these metals associated with every crude–in essence constituting an individual metallic trait. There are other chemical and physical properties for the various crudes, but these are subject to change during weathering/aging [sic]. The metallic components, however, are stable and are not affected by weathering. By simply comparing the metallic content of the spill against [sic] that of the suspected source, it is possible to limit the probable source to a specific vessel, pipeline or storage facility.[21]

Others have proposed analyzing even larger metallic suites, for example, vanadium, sodium, manganese, and cobalt; this method was proclaimed to offer

> definite promise for the trace-element characterization matching [sic] of an actual oil-slick sample with one sample of fuel oil–out of a number of suspect samples. . . . The various characterizing trace elements, occurring in the original crude oils largely as essentially non-volatile metal porphyrins, remain in the residue left when the volatile components of the crude evaporate (as from an oil slick), and when the light ends are distilled of in refining. Thus NAA [neutron activation analysis] matching of the levels of these trace elements–between an oil slick and its polluting source–may, for the first time, provide a method of identification of the source of oil pollution of waters that will aid in the enforcement of present oil pollution laws.[22]

While the idea of using vanadium and nickel to identify oil slicks has, at the very least, the merit of being based on some firm fact–for vanadium and nickel are very commonly found in oils, and they are often found (in small part) as metalloporphyrins, of which they are by far the two most stable[18]–these other metals, especially sodium, are very poorly advised. Sodium, for example, is common in petroleum but it is also the most common cationic metal in sea water;[23] it is therefore readily available to participate in exchange and replacement reactions with the oil slick. The petroporphyrin nucleus is an obvious target for exchange reactions with sodium ions from the sea; unfortunately, these sodium porphyrins are not very stable in the presence of other cations.

Hodgson[18] and his colleagues have brilliantly summarized the evidence: It is thoroughly established that alkali metal ions in porphyrin molecules are readily replaced by other cations; the metalloporphyrins, in order of increasing stability, is alkali metal, large divalent metal, and finally small divalent metal; and complexes of porphyrins incorporating monovalent cations show rapid exchange.

It has been known since the late 1940's that both the mono- and di-salts of porphyrins with alkali metals are very unstable and break down in the presence of water. While other petroleum compounds of sodium may be more stable than sodium porphyrin, it is well to remember that one general characteristic of sodium compounds is their water solubility, and water-soluble compounds are not likely to remain in an oil slick for long.

The Relevance of Market Statistics

Quite aside from the physical and chemical stability of metals in petroleum, there is the problem of distinguishing two or more samples that may be very similar. While the vanadium/nickel ratio of Kuwait petroleum is quite different from the corresponding ratio in Venezuelan petroleum, the U. S. does not import equal amounts of petroleum or petroleum products from these two countries. For example, about 80 per cent of the residual fuel oil imported into the U. S. comes from Venezuela and the Netherlands Antilles, and over 90 per cent of all the residual fuel oil that is imported by the U. S. is received in PAD District 1 (roughly, the New England, Middle Atlantic, and Southeastern States).[24]

Imported residual fuel oil is far more likely to be spilled in an East Coast harbor than in a Pacific harbor, and the oil is very probably a South American export. Similar considerations apply to other petroleum products. Sumatran crude oil, for example, is imported almost exclusively into the Pacific region; Venezuela and Canada together account for about two-thirds of the crude oil imported into the U. S. Exactly the same argument also applies to oil produced within the U. S. Texas, Louisiana, California and Oklahoma together produce about 80 per cent of our crude oil. Much of this oil comes from such giant fields as Wilmington, East Texas, and Kelly-Snyder. It is therefore likely that a spill of U. S. crude oil is a spill of oil from Texas, Louisiana, California, or Oklahoma, and it is quite likely that this oil came from one of the major oil fields in those states.

The more specific the argument gets, the greater the likelihood becomes. For example, most of the crude oil that is processed by the great refineries of Eastern Pennsylvania and New Jersey is sent via tankers and barges from Texas and Louisiana; it therefore follows that a spill of crude oil on the Delaware River almost certainly involves Texas or Louisiana crude, and very probably involves a crude oil from one of the large oil fields in those states. How can vanadium/nickel ratios be used to distinguish one Wilmington crude from another, or one Venezuelan residual fuel oil from another? The economic realities are not especially relevant to a pure chemical argument, but in a discussion of the probability of oil spills, they should not be entirely forgotten either.

Sulfur-Isotope Ratios

Keeping this discussion of economic realities in the back of our minds, we can proceed to the use of sulfur isotopes as passive tags. This discussion is heavily based on the work of Thode and his colleagues[25-28] at McMaster University (in Hamilton, Ontario), who have been studying sulfur-isotope ratios in a variety of geologically important materials, including petroleum, since the later 1940's. As in our discussion of metallic suites in petroleum, we have chosen the work of disinterested scientists whose work was conceived and published without oil tagging in mind. Thode and his colleagues have undertaken a purely geochemical investigation of isotope fractionation.

Isotope fractionation is an established and important geochemical process: Oceanic carbonate is rich in 0-18 with respect to ocean water, plants are enriched in C-12 with respect to atmospheric carbon dioxide, and sea sulfate is rich in S-34 with respect to the sulfur found in meteorites and basic igneous rocks.

Although there are nine sulfur isotopes, only four of them (S-32, -33, -34 and -36) occur in natural sulfur; all four are stable, but they are not equally distributed: S-32 predominates (95.0 per cent), and S-34 (4.22 per cent) accounts for most of the remainder. The ratio of these two most common isotopes is often standardized with respect to meteorites because this ratio is virtually invariant; in the Earth's mantle, however, the content of S-34 varies by approximately 100 per cent. The 34/32 ratio has been studied in many materials, including petroleum and sea water: In sea water the ratio is +20 ±2 per cent, while in petroleum it varies from -8 per cent to +33 per cent—indeed, it varies from -8 per cent to +28 per cent in petroleums from Utah alone! And the apparent significance of this phenomenon has not been lost on proponents of passive tagging.

The fundamental fact in the geochemistry of sulfur isotopes is that S-34 tends to sulfate and S-32 tends to sulfide: S-32 is the more readily reduced isotope and S-34 is the more readily oxidized. 34-Sulfide plus 32-sulfate tends to 32-sulfide plus 34-sulfate. In short, the heavier isotope is more readily oxidized, and the lighter isotope is more readily reduced.

While all the sulfur compounds in petroleum have not yet been identified, all the identified sulfur compounds are reduced: thiols (mercaptans), disulfides, sulfides, and thiophenes.[15] The ultimate source of this sulfur is not definitely established, but many authorities have argued that it must usually be oceanic sulfate, reduced to sulfide by such bacteria as *Desulfovibrio desulfuricans;* Davis[7] has beautifully summarized the evidence. These bacteria preferentially metabolize the lighter mass isotope, viz, S-32, and it has been shown by several investigators that this preference is usually around 15 per cent;[29] the 34/32 ratio in petroleum should therefore be about 15 per cent lower in petroleum than in the sulfates of ancient oceans.

The group at McMaster University has shown that this is usually the case. This group has shown that, while the absolute sulfur content of petroleum declines with time, the sulfur-isotope ratio stays remarkably constant. They have also shown that the content of sulfur isotopes in Devonian petroleums extending from the 49th Parallel to the Arctic is nearly constant, and have argued that the most reasonable explanation for this phenomenon is a large sea, which provided the large reservoir of sulfur of uniform isotopic content and constant oil-forming conditions. They were therefore pleased to announce that the isotope ratios in Ordovician and Silurian oil of Texas and Ontario, although separated by several thousand miles, were quite similar.

What is the conclusion to be drawn from this evidence? It is, quite simply, that S-isotope ratios are just another general index of geological age. Geochemists have several such indices (e.g., ratio of complex cyclic structures to simple chain structures, not to mention radiocarbon dating). It is difficult to see, however, how any such index can be of much use in identifying oil spills. For example, our largest foreign source of oil (Venezuela) is a major shipper of Tertiary crude; so is Louisiana, our second most productive oil state.

Our second largest foreign source of oil (Canada) sends large quantities of pre-Mississippian crude to our East Coast refineries; so does Texas, our largest oil-producing state. Miocene oil is common in Louisiana; it is also common in Indonesia. Are S-isotope ratios sufficiently precise to distinguish Miocene from Eocene? If not, oil from Fresno, California, can't be distinguished from the oil of Sanga Sanga, Borneo, or Plaquemines Parish, Louisiana.[24,30]

There is another objective, however, that may be even more important. The sulfur in oil is reduced, but when oil is spilled at sea, the sulfur is put in an oxidizing environment. Because of kinetic isotope fractionation, the S-34 will be more readily oxidized that the S-32, other things being equal. The logic of this process leads us to conclude that the more the spill is oxidized, the lower the 34/32 ratio will be; a week-old oil spill should have a lower isotope ratio than a day-old spill from the same source. If the fractionation effect were strong enough, the delta-value might go from highly positive to very negative. This combination of geochemical fact, oxidation kinetics, and petroleum-trade statistics leads us to conclude that sulfur-isotope ratios could not very well be used to prove a violation of oil-pollution laws.

Special Cases

While we do not know of any easily identified passive tag that is unaffected by harsh or extended weathering, several kinds of passive tags can be used profitably as presumptive tests on the identity of oil spills under special conditions. In general, the requirements on passive tags should not be different from the requirements on active tags: Both kinds of tags should be unchanged by weathering and microbial oxidation, soluble or dispersible in oil, insoluble and nondispersible in water, and involatile.

However, there are special circumstances in which some of the requirements on passive tags may be replaced. Where oil pollution is infrequent, where there are few possible sources of pollution, and where weathering may be assumed to be inconsequential or insignificant (because of the slick's freshness), several methods of chemical analysis—supplemented by a great deal of convincing circumstantial evidence of an extra-chemical kind—may identify oil slicks by passive tags in the spilled oil.

Chemical analysis is useful when it does not have to bear the whole burden of proof. For this reason, we cannot agree with authorities who propose a combination of analytical techniques (such as gas-liquid chromatography, controlled pyrolysis, mass spectrometry, and computer calculations) to yield a "fingerprint" of the slick.[31] If the spill has not been extensively weathered and if there are not many possible sources of pollution, the combination of analytical techniques is wasteful: Where the circumstantial evidence is convincing, extensive chemical analysis is not required. However, where there are many possible sources of pollution, where pollution is frequent, and where the spill may have been weathered for days or weeks (or mixed with other spills, some of which may have been weathered), it seems highly improbable that any combination of analytical techniques could stand up in court to a carefully reasoned chemical defense.

The problem of mixed and continuous pollution is not unknown. According to Ludwig and his colleagues,[32,33] the beaches in Southern California are commonly polluted by a mixture of oil and asphalt from natural seepage, liberally supplemented by tanker and drilling wastes. One would expect that similar conditions frequently pertain along the Gulf Coast. A senior scientist at the Woods Hole Oceanographic Institution was recently reported[34] to have said that he could not sail anywhere in the Atlantic—even a thousand miles from land—without finding oil. The methods we shall discuss cannot be recommended for such areas as Southern California, nor for areas that are frequently afflicted with oil pollution.

To begin, all the methods of passive tagging we have already discussed can be used (although they are more expensive than several other methods) as long as there is plenty of independent evidence that the oil slicks are fresh and have not been mixed with other oil pollution. Other simpler methods of identification were published in the U. S. and England in the early 1950's; these methods make use of simple techniques of paper chromatography.

Schuldiner[35] reported (in 1951) a simple method of spot chromatography that had produced evidence for prosecuting and convicting oil polluters in Baltimore, Maryland, and the upper Chesapeake Bay area. He sampled the oil slick, then boarded suspected ships and sampled bunker fuel oils, bilges, loose oil on the decks or sides of the vessel, on fuel intake valves, and on adjacent docks. The samples from the slick and the ship were strictly treated as comparison samples. Small spots of the samples were applied to blotting paper, allowed to develop completely (i.e., to stop spreading), and were then examined under ordinary and UV illumination. He found that various crude, semi-refined, and refined petroleum products gave characteristic spot chromatograms, and that the chromatograms from known crudes invariably gave identical radial fluorescence patterns.

While Schuldiner's chromatograms can be effective, they are not perfect: They entail at least three troublesome problems. First, confluent multiple spills will give chromatograms that are characteristic of the mixture, not of the components of the pollution; it is very doubtful that the chemical mixture can be resolved into its legal components, or that a given slick can be proved not to be a mixture unless the circumstantial evidence is overwhelming. (This objection applies with equal force to all other methods of passive tagging.) Second, any but the freshest slicks may have become viscous and emulsified, may have experienced considerable evaporation, and their asphaltenes and other heavy components may have agglutinated into a discrete particulate phase;[36] the chromatograms of the slick and the source are likely to differ unless the slick is fresh, and the size of the difference will largely depend on the slick's age. Moreover, if the slick is very viscous or emulsified, it will have to be filtered, extracted, heated, and/or dissolved in a non-fluorescing solvent in order to be chromatogramed; while this treatment may not be damaging, it is not helpful to the prosecution's case either. Third, it is not an unmixed blessing that identical chromatograms are invariably produced by crudes from a given area. If all (or even many) Venezuelan crudes give identical chromatograms, and if two or more tankers carrying Venezuelan crude have recently been in the area of a spill, it is not clear how one ship rather than the other could be blamed.

Another simple chromatographic method, paper-strip chromatography, was independently published in 1953 by Herd,[37] who claimed that he had used this method to identify fuel oil that had been spilled in the harbor of Wellington, New Zealand. While Herd was apparently ignorant of Schuldiner's work (in any event, he did not cite it), his claims are strikingly similar, and he asserted that his method "gives visual evidence of complete identity or of non-identity and, if necessary, the strips can be used as evidence in a court of law."

All the reservations that apply to Schuldiner's methods apply just as strongly to Herd's. One further reservation merits special attention: Herd's methods "identify" only the ether-soluble portion of the slick. Although the ether-insoluble fraction of a slick is admittedly difficult to work with in the analytical laboratory, it can provide valuable information (particularly on naturally occurring microsolids); in any event, it does not seem prudent to ignore it altogether because it can be a sizable fraction of the slick. Ludwig & Carter[32] have reported that 12 crude oils contained (on the average) 7.9 per cent ether-insoluble material, that some crudes contained as much as 15.5 per cent ether-insolubles, and that one film of oil collected at a beach near Santa Barbara contained 6.5 per cent ether-insolubles.

Active Tagging

The reader may already have surmised that we have reservations about the validity and efficacy of passive tagging, and he will have been correct. Oil pollution, like the Devil, is said to be legion, and it is no less treacherous to identify absolutely; identification based on passive characteristics seems to be especially worrisome because the passive tags are quite likely to mingle, to evaporate, to be dissolved, or to be oxidized at sea; furthermore, even if these processes do not occur, they create formidable forensic problems for the prosecution, and telling counter-arguments for the defense.

Although God, nature, and geochemistry have not conspired to simplify the forensics of oil pollution, we may, with due humility and caution, come to our own aid. For if the intrinsic components of the oil slick do not lend themselves to reliable identification, we must consider the possibility of introducing additives (active tags) that will suit our purposes. What does one require of an active tag? Ideally, it should satisfy ten criteria.

1. It must be an unusual material that is never found in the environment and is found only in the petroleum to which it has been added.
2. It must be compatible with (i.e., chemically unreactive and physically stable) and soluble or dispersible in the oil.
3. It must be both insoluble and nondispersible in water.
4. It must be relatively involatile.
5. It must be stable to chemical, photochemical, and microbial degradation in the oil-slick environment.
6. It must be easily detectable in extremely small quantities by readily available analytical techniques.
7. It must permit modifications so that when it is added to a particular oil shipment it provides a unique code or "license plate" for that carrier or transporter.
8. It must remain with the oil during the course of its history following a spill.
9. It must in no way interfere with the end-use applications for that oil, nor complicate further processing and refining.
10. It must be available in quantity at economical prices.

While few tags will be ideal, all candidate tags must satisfy all criteria to some degree.

We have investigated two types of oil-soluble tags and one type of particulate tag, and find some (though unequal) merit in each.

Halogenated Aromatics

Over the past several decades, many studies have been performed to identify and characterize the constituents of petroleum. Although many types of aliphatic, aromatic, and heterocyclic compounds have been identified, there is no evidence of halogenated, polynuclear aromatics in crude oils. This class of compounds has many other characteristics that repay careful attention.

First, polynuclear hydrocarbons are (in comparison with aliphatic hydrocarbons) quite stable to oxidation.[38] This stability is due, in part to the resonance and bond-dissociation energies of the aromatic system, whose resonance energies increase markedly as the number of condensed rings increases.[39] Halogenation of aromatic rings has, in common with nitration, sulfonation, and acylation, the great advantage of stabilizing the ring against further attack;[40] it also increases the involatility of the parent hydrocarbon, but (in general) does not affect water-insolubility or oil-solubility.

An important feature of halogenated polynuclear aromatics is that there are many different ways to substitute F, Cl, Br, or I (or their combinations) on condensed aromatic nuclei, thereby providing a large number of specific tagging compounds. Moreover, there are many isomers of each parent hydrocarbon. Depending on the parent hydrocarbon, a large number of mono-, di-, and poly-substituted isomers can be produced with halogens, singly or, *a fortiori*, in combination. The simplest possible example, naphthalene, has two products of monosubstitutions ($C_{10}H_7X$), ten products of monosubstitution ($C_{10}H_7X$), ten products of disubstitution ($C_{10}H_6X_2$), and 14 of the mixed type ($C_{10}H_6XY$), where X and Y are any two halogens. There are 42 known and fully identified polychloronaphthalenes; it is obvious that larger condensed systems (say of six or more rings) offer even more structural isomers for selective halogenation. Even the monochloronaphthalenes have boiling points above 250°C (482°F), and further halogenation raises the boiling point correspondingly; the vapor pressures similarly decline with increasing polycyclic condensation.

The stability of overcrowded halogen compounds (e.g., octachloronaphthalene) has also been demonstrated.[41] In view of the various polycyclic nuclei (and the several structural arrangements that are possible for each) that may be halogenated, and the numerous possibilities for halogenation (involving single or several halogens), it is clear that a large family of coded compounds that can readily distinguished from natural petroleum compounds can be synthesized.

We recall that active tags must be identifiable in the slick even after long exposure to the elements and weathering, which ordinarily increases the concentration of asphaltenes in the slick. Petroleum asphaltenes are polycyclic, comprising mostly aromatic rings[42] in a pericondensed sheet configuration.[43] In general, these asphaltenes might present a considerable background problem. However, the analytical technique suggested for the detection of halogenated active tags should minimize this problem, viz, gas chromatography using an electron-capture detector.

The electron-capture detector is a substance-specific device that is sensitive to certain types of molecules containing electrophilic atoms or groups (e.g., halogens, carbonyls, nitro groups, etc.) and certain condensed-ring aromatics, metals, and the like.[44-53] It has a very low sensitivity for hydrocarbons other than aromatics.[54] Furthermore (and very important), the detector is extremely sensitive to halogen substituents: It can reliably detect halogenated hydrocarbons in quantities as low as 10^{-10} to 10^{-12} gram;[55] under optimized conditions, a projected sensitivity of 10^{-16} gram has been reported.[44] Electron-capture gas chromatography has been used successfully to determine parts-per-billion concentrations of chlorinated insecticides in waste water samples,[56,57] and chlorinated hydrocarbons in air samples.[58]

Since gas chromatography has been used extensively to separate and characterize the components of petroleum and its products,[59, 60] it can be used with reliability and precision to separate the components of an oil-spill sample. Coupled with the extreme sensitivity afforded by the electron-capture detector, gas chromatography can be used to ascertain the presence of an active tag by virtue of the tag's structure and substituents. Detection and identification of the tag can be expedited by reference to a catalog of retention times of the several tagging compounds on a standardized chromatographic column.

When an oil sample is brought in for analysis, the retention times of the various chromatographic peaks of the sample can quickly be compared with the catalog, and the proper component peaks identified. The correlation between chemical structure and column retention times (or elution values) is well documented.[61,62] Halogenated aliphatics,[63,64] heterocyclic compounds, and unhalogenated polynuclear aromatics (as well as inorganic halogens) should not interfere because their retention times (and their detectability by the electron-capture device) will not correspond to the tag's behavior. However, if several peaks should occur near (or overlap) the tag's peak, these particular fractions can be collected and rechromatographed under operating conditions that will give a better separation.

Although nothing is known experimentally about the stability of halogenated polycycles in an oil-spill environment, there are excellent theoretical reasons for believing that these compounds will be stable. In general, aromatic structures are stable to oxidation at ambient temperatures and pressures; halogenation further protects the aromatic nucleus from chemical attack. There are excellent grounds for believing that halogenated tags will be much less reactive than the rather inert condensed aromatics that are naturally present in oil, often in large quantities. Since condensed aromatic compounds are not easily attacked by microorganisms, and since halogenated aromatics are even more stable than the corresponding parent hydrocarbons, there is also excellent reason for believing that the tags will be stable to microbial attack. All of this, however, is theoretical conjecture, not proven experimental fact.

Because of the great sensitivity of the electron-capture detector to halogenated compounds, it should be evident that very little of the tagging material is required to tag a large volume of oil. For example, the largest tankers now on the drawing board will hold 500,000 tons of oil. How much tag must be added to identify such immense cargoes? The theoretical limit of detection by electron-capture gas chromatography is 10^{-12}. Therefore, 0.016 *ounce* of tag is (theoretically) sufficient to tag a half million *tons* of oil. But why push the limit of detectability? Why not allow a safety factor of three orders of magnitude? Why not, indeed, because then only one pound of tag (about one pint) will safely do the job. And "safely" is very safe: One gram of oil slick (about ¼ ounce) will contain one nanogram of tag, and one nanogram of a halogenated aromatic substance is extremely easy to detect by electron-capture gas chromatography.

It is not without interest that electron-capture gas chromatography is several orders of magnitude more sensitive than emission spectroscopy[65] and approximately two to three orders of magnitude more sensitive than ordinary neutron-activation analysis[66,67] (i.e., activation that does not use very fast neutron fluxes.) By combining gas chromatography with mass spectroscopy, the tags can be absolutely identified.[68,69] Just as important, because of the sensitivity of the electron-capture detector, the tag can be used in extreme dilution, and can therefore be added to the oil in amounts which will not interfere with further processing or uses of the oil.

Organometallics

Halogenated aromatic molecules are not the only attractive class of oil-soluble tags. In 1962, a group at the National Bureau of Standards,[70] in collaboration with the American Petroleum Institute, developed a number of stable, oil-soluble organic compounds (mostly organometallics) for use as analytical standards in the spectrographic analysis of petroleum products. The trace elements include Al, Ba, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Hg, Ni, P, K, Si, Ag, Na, Sr, Sn, V, and Zn; as cyclohexanebutyrates and/or ethylhexanoates, these metals make spectrographic standards that have the following properties: Each is reproducable, stable, nonvolatile, oil-soluble, and compatible with all the other spectrographic standards in this series.

Many of these metals can be detected spectrographically in extreme dilution (parts per million or less), so that one gram could be used to tag a ton or more of petroleum. The 28 compounds that were selected as standards were chosen from an initial list of over 150 candidates; many of the candidates that were rejected as spectrographic standards may still be useful as active tags for oil spills: One of the principal reasons for rejection was extreme chemical purity (e.g., the metal naphthenates), and this requirement might be somewhat relaxed for oil-spill tags. These 28 standard samples, prepared in solid form for easy weighing and handling, may be purchased for $2.00 a gram from the National Bureau of Standards. Obviously, in mass production (with some relaxation of the requirements for extreme chemical purity), the price might be significantly reduced.

Even though all this work on spectrographic standards has made the use of certain organometallics an attractive possibility, there are still several problems and doubts that must be resolved. First among these is the problem of solubility. Only a few of the Bureau of Standard's organometallic standards could be dissolved in oil, without heat or other solvents. If the standard were dissolved in a solubilizing agent (such as a free carboxylic acid, a diketone, or an ester) and then diluted with the base oil, however, the resultant solutions had optimum stability and highest concentrations of trace metal.

The solutions were judged satisfactorily stable if a solution of at least 500 ppm of the trace metal of interest remained "clear and devoid of visible change during several weeks at room temperature." An excellent solubilizer and stabilizer was found to be an equimolar mixture of bis (2-ethylhexyl)amine and bis(2-ethylhexyl)dithiocarbamic acid in an equal volume of xylene. It is not clear, however, what the highest stable concentration of metals might be. A related question is more importat still: What happens to the analytical standard once the solubilizers and stabilizers have evaporated, as is likely after a slick has aged on the sea for several days? Will the standards gel or precipitate?

A second major problem is background: Most crude oils contain traces of inorganics (especially metals), and some crudes have more than 0.5 per cent ash; there are several excellent reviews of the literature on this topic.[13,14] Many refined petroleum products also contain metals, either deliberately added (e.g., components of additives to impeded corrosion and oxidation or to improve lubricating properties), or adventitiously present (e.g., volatile organometallics in the crude that were not removed during refining). How can this background be distinguished from the active tag? Analysis of petroleum shipments for the presence of background interferents is obviously not the answer. It is much too costly, for one thing, and for another there is no guarantee that the metallic suites in the oil slicks will be identical to those in the unspilled oil. Indeed, there is every reason to believe that the suites will be drastically different.

A better solution is to separate the tag from the slick (by chromatography, for example) before attempting further identification. Since the tag is a chemically stable "known," and since the organic moiety of the tag (e.g., cyclohexanebutyrate) should be rare in petroleum, there is no reason to believe that background suites will invalidate this method of tagging. However, separating and concentrating the tag from each slick sample adds to the time and cost of identification; since there are several thousand oil spills in U. S. waters each year, the problem of time and cost is not inconsiderable.

Radioactive Tags

Radioactive isotopes have been examined for possible use in a tagging system, and eliminated for two broad reasons. First, there are not enough isotopes with the right half-life to make the system work and second the use of radioactive material in public places is political dynamite.

Ideally a radioactive tag has a lifetime of 90 days, a reasonable cost, is easily detected, and readily available. Lifetime of all tags should be about the same so that the relative abundance of isotopes does not vary with time. Thus, a minimum tagging system would have 30 or more tags available with half-lives between 70 and 110 days. Of 1700 isotopes examined, 15 have half-lives of 70 to 110 days and, of the 15, a majority were either too expensive or too difficult to detect.

Politically it is not wise to put radioactive material in oil when there is any possibility that the radioactive material might escape into the air or water. Recent experiences in Japan with the visit of nuclear submarines show how sensitive the public is about radioactive contamination of water.

Particulate Tags

Before discussing active particulate tags, it is well to say a little about the particulate material that is naturally found in petroleum. *The* basic reference on this subject is a 1937 paper by J. M. Sanders,[71] to whom all more recent are heavily indebted. In general, the particulate matter in petroleum consists of spores, pollens, fragments of tissue, hairs, microalgae, bits of feathers, etc. In addition, much of the particulate matter is in the form of asphaltenes, which are identified as suspended solids, colloidal particles, or solute molecules, depending on the investigator and his techniques.[43] Although these particles can convey a wealth of information to the careful investigator, their relatively small number and wide variety prohibit their use as particulate passive tags; furthermore, an oil spill may entrain pollens, spores, and other biological matter during its exposure to the elements.[72]

Adding well-characterized particles to oils is a promising technique. In the first place, these particles can be easily manufactured under current technology; second, they can be added to oil in small, measured quantities; third, there is good evidence that, if the need arises, they can be isolated from the oil matrix in quantities sufficient for very specific identification.

Active particulate tags share all the advantages of active oil-soluble tags (viz, specificity and small amounts of tag for proper identification), and offer several other advantages that might make them more suitable. Foremost among these advantages is the ease with which such particles may be produced by one basic technique: grinding and spheroidizing of solids produced from an appropriate liquid melt.

Rather homogeneous solid material can be obtained by: 1. solidification of a liquid melt, 2. coprecipitation from solution, 3. efficient mixing and sintering of suitable solids, and 4. deposition from a vapor phase; almost any such material may then be spheroidized.

We strongly recommend that particulate tags be prepared as microspheres for several reasons: 1. their small surface area per unit volume and lack of areas of large surface curvature make them relatively insusceptible to chemical reactions; 2. these same qualities make it rather unlikely that they will clog or impact upon passage through small apertures, or adhere to interfaces; 3. microspheroids are much more readily sized (e.g., by sieving, sedimentation, and microscopic methods) than any other shape; and 4. the technology for producing them is eminently feasible, and so is the technology for characterizing them.

The flowability of microspheroids makes them ideal for unit operations where mixing is necessarily of importance; flowability is obviously important where trace solids are to be added to a very large amounts of liquid. All these points also apply to simplifying the preconcentration and isolation required in any analysis of suspensoids. Finally, small particles (10-50 microns) are not rare in nature; but very smooth microspheres of this size are much less common.

The most common process for making microspheres is liquefaction of a particle followed by solidification in a dilute, slowly moving gaseous "suspension." Other common techniques are: tabling to produce Lucite spheres; deposition from liquid solution for certain resins; and mechanical action, as when polishing compounds used in ball mills produce ceramic or glass spheres. There are also several methods for makig microspheroids from metals.

Many materials have been made into microspheroids: soft and hard glasses[73-75] (which may be "doped" with a wide variety of metallic salts), metals,[76,77] ceramics, nitrides, carbides, celluloses, starches, polystyrene, phenolic resins, and many other organics.[78] Many suitable microspheres are already commercially available; others can be expeditiously made by custom synthesis. Their costs range from a fraction of a cent a pound (for some commercially available materials) to $1,000 a pound (for custom synthesized rare metal microspheres).

Exact methods for analysis and identification of oil spills that contain particulate tags depend on many factors. A thumbnail sketch of what, at this time, appears to be a reasonable procedure follows:

1. Microspheres of about 10 microns diameter would be produced by spheroidizing a suitable, finely ground and sized solid.
2. These particles would be characterized in preliminary tests to ensure proper quality control over such critical factors as particle diameter, density, content of trace additives, etc.; the data would then be carefully cataloged.
3. The particles would then be metered into the specified petroleum (preferably as it passes through a pipeline or as it is pumped into a tanker). In order to have, on the average, 10^3 particles per liter of oil, only about 5×10^{-4} gram of particles needs to be added to each ton of oil; this amounts to 50 grams for a 100,000-ton tanker.
4. Upon spillage, a representative sample would be taken from the slick; the sample need not be much more than a few liters.
5. The particles in about a liter of spilled oil would then be preconcentrated as follows: 1. centrifugation and washing with a light hydrocarbon; 2. washing with more digestive liquids (perhaps acids or bases); 3. a terminal filtration and wash on a Millipore filter; and 4. transfer of the solids to suitable microscopic mounts.
6. Analysis (as in step 2) to identify the particles. These tests might include microscopy (for size and shape, color, phosphorence, fluorescene), microanalysis (for density, hardness, trace analysis), or microspectrometry (light absorption, fluorimetry, reflectance). Microspectrofluorimetry could provide a characteristic spectrograph of just one or of a number of particles; such a trace would, indeed be a "fingerprint."
7. The data from the preceding step would be compared with the data catalog (see step 2).
8. In the case of a multiple, confluent spill, the individual offenders could be identified readily provided that only one type of tag had been added to each oil. To determine how much of the spill was due to each offender would involve characterizing a larger, representative sample of microparticles; based on the number density of each type of tag, proportional liabilities could be estimated.

Microspheroidal tags permit of a very large number of identifiable forms. Considering only particle sizes of 10-50 microns with an error of ± 2.0 microns for a given size, there are at least 11 distinct and well-defined sizes.[79] For density, given a rage of 0.9 - 1.50 grams/ml and an error of ± 2 per cent, we have, again, at least 11 possible characterizations.[80] The product of 11 sizes and 11 densities is 121 distinct particle types. In addition to these types, particles may contain trace amounts of chemically detectable materials, which may be characterized qualitatively or quantitatively. A series of microtests could easily determine whether or not 20 or so readily identifiable trace chemicals are present in the particle.[81-85] With a very simple binary code (in which each of the trace chemicals is merely determined as "present" or "absent"), 20 trace chemicals permits 2^{20} (1,048,576) possible particle characterizations. In combination with the 121 basic particle types, trace-chemical binary coding gives well over 100 million types of identifiable particulate tags.

Addition of Active Tags to Petroleum

The metering of small amounts of liquids has been developed by the chemical, pharmaceutical, and processing industries; ideally, the tags would be injected into the oil as it passes through a pipeline or as it is pumped into a tanker). For the particulate tags we recommend (2-50 micron spheroids), the same techniques will suffice.

Addition of a tracer material to petroleum involves two similar and related critera: First, the tracer should be in a homogeneous phase, and second, this carrier phase should be injected uniformly into the petroleum so that the resulting tagged dispersion (or solution) is also uniform.

There is ample evidence that relatively stable dispersions of particles in a petroleum-based liquid are easily produced. It is important that this stability be maintained when the carrier fluid is injected into the petroleum. Surfactants are critical to stability.[86] In crude oil, enough surfactants (such as porphyrins) are usually present to assure stability (at least for the dilute suspensions we are considering); in refined products, it may be necessary to select the particulate tag with great care so that the appropriate surface properties (hydrophobicity and oleophilicity) pertain. Highly polar materials (e.g., ionic salts) actually stabilize suspensions when the particles are larger than about one micron; the only important exceptions are metal sols, which, however, are stabilized by organometallic molecules.

According to Koelmans, "... a [disperse] system is stable when a crossing of the potential barrier between the particles by thermal motion alone is very improbably;"[84] this potential barrier is about 15 kT for a modestly charged double-layer and is much greater than the usual thermal energies (about 1 kT). This energy difference also applies to particles approaching an interface: Thermal energies cannot overcome the surface potential barrier. Very concentrated suspensions (20-90 weight percentage) may be stabilized by adding small quantities of dissimilar particles;[88] this stabilization technique may be of value in prescribing carrier suspensions.

Once a stable carrier suspension has been produced, it can be metered into petroleum without further problems. Many metering pumps are available at nominal cost; some of these (through mechanical action on a disposable diaphragm, bladder, or flexible tube) do not even contact the metered fluid. Since the volume of the metered suspension or solution may be increased almost at will, pump capacities are not of special importance. Sufficiently stable particle suspensions can be produced and then metered into the petroleum which is to be tagged; since this latter step represents a very large dilution, the resulting suspension is expected to be very stable.

Costs of Particulate Tags

The materials' cost for particle tagging should be quite small. The matrix of the particles will probably be a quite common plastic or glass, and would cost a few cents to a few dollars a pound. The trace materials imbedded in this matrix would cost about the same but would be used in almost negligible quantities. The capital outlay for equipment is more expensive. For instance, laboratory apparatus to produce the microparticles would run in the neighborhood of $5,000. A microspectrofluorimeter with a lens system for single-particle measurements might cost $30,000; however, spectrographic analyses of the desired type may be purchased commercially for about $50 a sample. High quality microscopic equipment would be absolutely necessary; it is available for $4,000 to $20,000.

Costs of Oil-Soluble Tags

Halogenated, polynuclear aromatic hydrocarbons vary enormously in price. While many halogenated benzenes can be bought for under $4 a pound, the halogenated polynuclear compounds can be quite expensive. For example, 9-bromoanthracene costs $1,000 a pound, 2-fluoronaphthalene costs $360 a pound, but 1, 3, 6, 8-tetrachloropyrene costs only $30 a pound.

Even the most expensive of these compounds, however, goes a long way in a tagging system. Approximately 0.001 pounds of tag in 50,000 tons of oil can be detected by electron-capture gas chromatography; even assuming the worst (the outrageous price of $5000 a pound for tagging material), $5 worth of tag would identify 50,000 tons of oil—so that the materials cost for tagging one ton of oil is 10 cents. Obviously, many halogenated tags can be had for a fraction of this extreme price. Excellent electron-capture gas chromatographs can be had for $5,000 or less, so that the capital outlay for detection equipment is not a serious problem.

The organometallic spectrographic standards that the National Bureau of Standards designed specifically for analysis of petroleum products are available from the Bureau for $2 a gram (roughly $900 a pound). These tags are detectable in dilutions of 10^{-5}, so that one gram of tag would identify about one ton of oil. The Bureau's spectrographic standards are exacting in the extreme, and these standards are not mass produced. By relaxing the requiremens for such extreme chemical purity and increasing the production schedule, it seems probable that significant cost savings could be effected. Analytical instrumentation for spectrography is widely available commercially at prices beginning at several thousand dollars, and are standard equipment in most analytical laboratories.

Cost of Active Tagging

Since the amount of tagging material that will be added to a ton of oil—whether the tags be particulate or liquid—is one part in a billion, the cost of the tagging material is low per ton of oil. Assuming the cost of tagging material is $4.53 a pound and one milligram of tagging material is added per metric ton of oil, then the per ton material cost is one thousandth of a cent per ton. Costs of adding the tagging material should be in the same order of magnitude. Including all the quality control, analysis, and service, the actual cost of adding a "license plate" should be less than a few cents per ton of oil.

Feasibility studies and demonstration of the system's efficacy should be run before the operational tagging begins. However, the economics and technology are such that the tagging of oil can begin now.

Tagging Codes

Apart from the type of material used for tagging, "codes" and "tagging profiles" will be involved in the system. Oil shipped into one port will be mixed upon unloading with oil from other tankers and hence the stored oil with its mixture of tagging codes will have its own unique tagging profile at a given time. Oil subsequently loaded onto a tanker will be re-tagged by the unique code assigned to the tanker. Thus, the re-tagged oil will have a new tagging profile whose dominant code will be that of the tanker that last tagged the oil. As a result, any oil or oil slick from a tanker will have an underlying tag noise with a superimposed tanker code. To identify the source—last jurisdiction–of the oil not only must the individual tags be identified but also the relative abundance of each tag.

When an unknown batch of oil is recovered for source identification and analysis is begun, two immediate questions arise: Is this oil spilled from a tanker? Who is the parent corporation? The first question arises because many ships, as opposed to tankers, spill oil, and the second arises because oil is within a corporate jurisdiction much longer than in a tanker jurisdiction. To speed up analysis a special tag would be used to identify all oil ever transported by tanker. Since there are a few very large oil companies, special tags could be assigned to each of the large companies, and smaller companies and independents could be grouped and given a special tag for their group. This would be in addition to the unique tag or code of tags assigned to a tanker. Thus, a quick analysis could answer the question as to whether the oil was ever shipped by tanker and which is the overall company in charge of the oil. If an independent tanker carried the oil this would be readily seen.

It would be very wise in setting up this tagging system to require each ship to tag its fuel oil at a bunkering station. This would eliminate confusion of tanker slicks and ship fuel oil slicks.

Tagging System

Each oil company and each ship would have its own tagging code assigned. Depending on the system, the code could be a unique tag or a code of tags. When a tanker loads an oil cargo, two taggings would take place: one by the loading station and one by the tanker.

Each tanker would have its pre-mixed and prepared code carried in sealed bottles. When loading is to begin, the coding bottle would be placed in the code metering pump and the coded fluid metered into the pipeline ahead of the pumps loading the tanker. The natural turbulence of the process would distribute the tagged material throughout the oil. Simultaneously the loading station would tag the oil with its own tag. A sample of the tagged oil would be taken for quality control and for subsequent comparisons with spills.

At each unloading, the oil from the tanker would be sampled and then tagged by the shore facility. The sample would be analyzed for quality control and for the record in case of a spill claim. Tagging during unloading would cancel the tanker profile and eliminate the possibility of false claims against the tanker for oil subsequently spilled.

Tampering with the tagging system would be difficult because tagging is difficult to do except during loading and unloading because thorough mixing is necessary. Furthermore, since a variety of tags are involved, it will be difficult to alter a batch of oil without its being obvious. Sophisticated analysis of the tags can be used to show that some of the tags are spurious. In other words, different batches of the same tag can have subtle differences that can be detected.

Conclusions

We have critically examined two approaches to identifying oil spills: passive tagging and active tagging. Passive tagging is a convenient circumlocution for no tagging at all: Nothing is added to the oil; the slick itself must provide all the evidence for its identification. Active tagging involves adding some known and readily identifiable material to the oil. The added material must satisfy several criteria: It must be soluble or dispersible in oil and insoluble and nondispersible in water; it must be chemically and physically stable in both spilled and unspilled oil; it must not interfere with the refining or with the commercial uses of petroleum; and it must not be too expensive. Two figures of speech are helpful in distinguishing active tagging from passive tagging: Passive tagging amounts to a "fingerprint," active tagging amounts to a chemical or physical "license plate."

Passive tagging does not seem promising, for the fingerprint is likely to be altered or to disappear as the slick is exposed to the abundant sources of chemical and physical energy in the sea and sky. The easily identifiable passive tags of petroleum (e.g., isotope ratios and trace metals) cannot be assumed to be stable in the slick–indeed, there is little doubt that they are unstable–and the more stable passive tags in the slick (e.g., heavy aromatic and alkylaromatic hydrocarbons) are prohibitively difficult to separate and identify.

Active tagging, however, offers several attractive possibilities. Making a good license plate seems much easier than finding a good finerprint. We have examined two types of tags: oil-soluble tags (organometallics and halogenated aromatic polycycles) and particulate tags (coded microspheroids). Several promising organometallics have been developed by the National Bureau of Standards in conjunction with the American Petroleum Institute; these compounds sell for $2 a gram, they are detectable in parts per million, and they seem to have all the properties of good active tags (compatibility with oil, solubility in water, chemical and physical stability, and ease of identification). The halogenated polycycles have never been used for analytical tracing in petroleum; consequently, no direct experience recommends them. However, they should have many desirable properties, and chemical theory recommends them. Their cost can range from a few dollars to a few thousand dollars a pound, but they are very readily detectable in parts per billion by electron-capture gas chromatography.

Although the feasibility of particulate tags has not been demonstrated in oil spills, coded microspheres appear to have exceptional promise: Many are already commercially available at very low prices; an astronomic variety of coded microspheres can be cheaply and easily made by custom synthesis; and all the particulate tags can be quickly separated from samples of slick and readily identified by available analytical techniques.

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Remote Sensing Of Oil Slicks

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Abstract

An overview of remote sensing methods is presented and illustrated with data taken at the Santa Barbara oil spill. The conclusion is reached that such methods possess monitoring capability but so for the ability to identify the slick material as oil has not been demonstrated. The advantages and disadvantages of each method are briefly discussed.

The tragic consequences of major oil spills, such as at Santa Barbara, are well known. The lesser but more frequent spills probably have equally tragic, if less dramatic, consequences in the long run. While major emphasis is on prevention and control of all spills, as it should be, a reasonable effort must be placed on the development of early detection systems. To this end, the FWPCA and other Federal agencies are investigating the applicability of remote sensing. Within the FWPCA there is interest in earth-bound and in airborne systems and the advantages of a satellite system are not overlooked. Earthbound instrumentation would be deployed in areas of high frequency or high probability of spills such as in harbors and near oil rigs. Airborne instrumentation, on the other hand, would allow occasional spot checks of other areas and effective monitoring of cleanup operations. Ideally, such instrumentation should be capable of detection, identification and of providing areal and thickness measurements. Remote sensing appears to have potential here and the purpose of this paper is to present an overview of these methods along with some experimental results.

Present remote sensing methods are based on the electromagnetic properties of matter. These properties are wavelength dependent, that is spectrally distributed, and in principle this dependence is uniquely related to the chemical species and the physical state of the oil film. Specifically, spectral absorption, reflectance, emission and/or scattering are the relevant properties with present emphasis on the wavelength range from 0.3 microns, in the near ultraviolet up to about 0.8 meters in the microwave region. The corresponding sensors or sensor systems vary from simple optical to very sophisticated electronic equipment as pointed out in Figure 1.

Passive Methods

Passive methods utilize naturally occurring radiation. In the range 0.3 to about 3 microns these methods sense the reflected energy from the sun and sky. A target is detected where a difference in reflectivity between target substance and neighboring scene points exist. These differences in reflectivity result in tonal or color contrast for photographic sensors and output voltage contrast for electronic sensors.

Panchromatic film or sensors do not respond to differences in quality of reflected energy and as a result, identification of slick material does not appear feasible with such devices. In fact, it is possible that no contrast is observed even when spectral differences in reflected radiation do exist. Figure 2 is a panchromatic photograph taken over the drilling platform at Santa Barbara during the oil spill of early 1969. The highly reflective material near the platform is due to dispersant and not to oil which is practically invisible in this picture. However, it should be pointed out that this picture, as all others presented here, was taken directly over the target resulting in minimum reflectivity. The reflectivity of films increases at oblique angles,[1] however, sun glint (glitter) can be a problem at these look angles usually leading to poorer quality photographs.[2]

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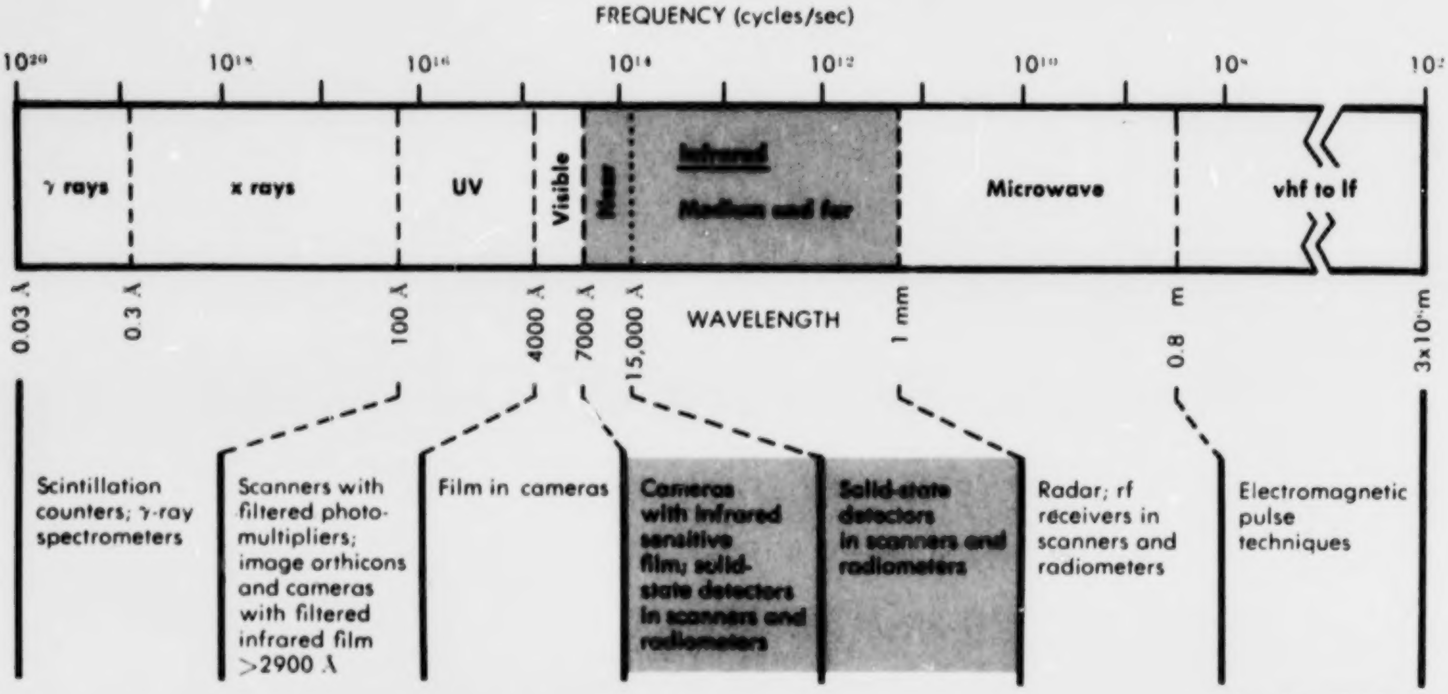
[1] Superior numbers refer to literature references at conclusion of text.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γ rays
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UV
Visible
Near
Infrared
Medium and far
Microwave
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0.03 Å
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1 mm
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Scintillation counters; γ-ray spectrometers
Scanners with filtered photomultipliers; image orthicons and cameras with filtered infrared film >2900 Å
Film in cameras
Cameras with infrared sensitive film; solid-state detectors in scanners and radiometers
Solid-state detectors in scanners and radiometers
Radar; rf receivers in scanners and radiometers
Electromagnetic pulse techniques

University of Michigan

Figure 1. The electromagnetic spectrum and some sensors that use it. The infrared portion of the spectrum, though much wider than the band of visible radiation, is still a small part of the total. Recent research has focused on the integrated use of several sensors, each making use of a different portion of the spectrum.

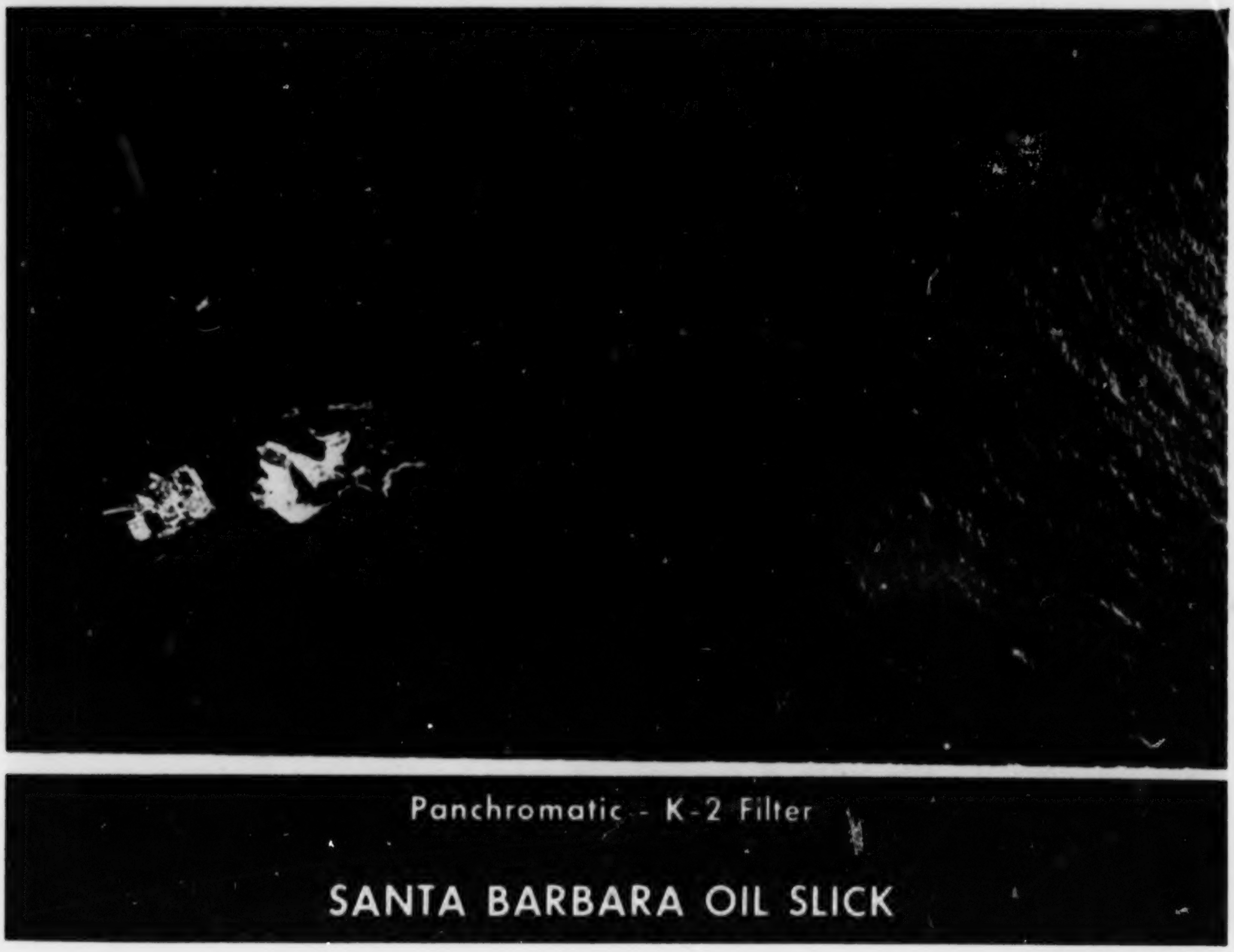

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Figure 2. A black and white panchromatic photograph taken over Santa Barbara. The highly reflective material near the platform is dispersant. There is very little, if any, indication of an oil film. Photographs taken at other than vertical look angles are frequently of poor quality due to sun glint as seen at the right of photograph.

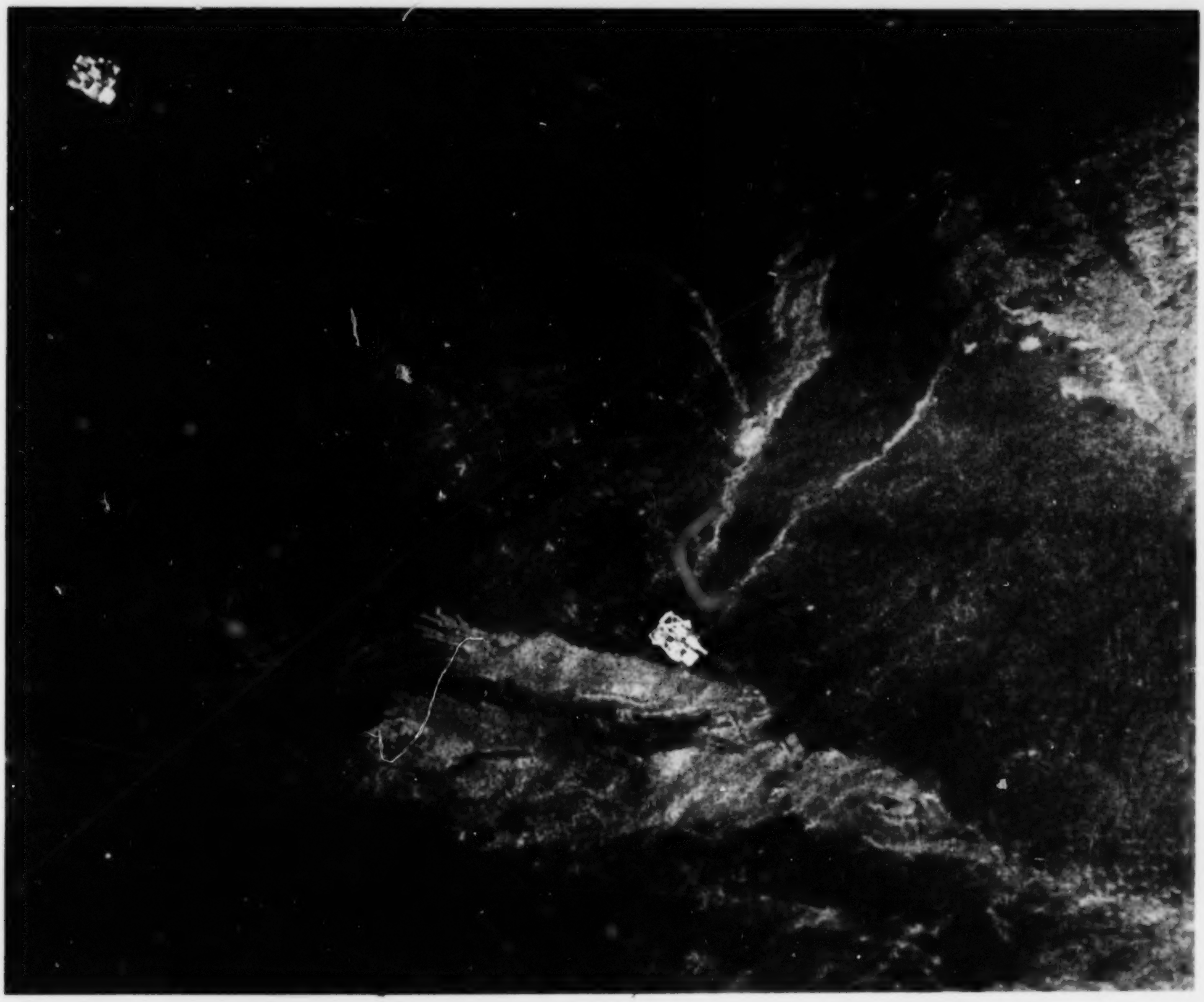

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Figure 3. Photograph taken at Santa Barbara. Films of varying thicknesses are shown.

Color photography offers an additional dimension. Figure 3 is a regular color photograph taken at Santa Barbara. Areas of thick oil film show as a grey-brown against the blue-green ocean. Areas of thin film are evidenced by the interference rings typical of such film slicks as in Figure 4.

The spectrozonal technique, an adaptation of color separation photography, provides somewhat greater discrimination than the usual color photography. A three or four lens camera takes simultaneous black-and-white transparencies in selected bands from .36 to .9 microns. Simultaneous projection through suitable filters produces a composite color image. Manipulation of filtration and channel intensity allows enhancement of density differences and consequently, greater target discriminating ability.[3] However, photography in general does not have the on-line feature required for rapid detection and at best provides data for post evaluation of cleanup procedures.

Multispectral methods divide the spectral range into many channels to fully utilize the differences in spectral reflectivities for target detection and identification. The University of Michigan system couples an optical-mechanical scanner with a spectrometer for the visible and near infrared region and utilizes filters in the far infrared.[4] Scanners, utilizing electronic detectors, allow a variety of outputs including black-and-white and color imagery and lend themselves to on-line data processing. Figure 5 illustrates the basic scanning procedure and the operation of a simple device.

A schematic of the University of Michigan system, including instrumentation for automatic processing of scanning information, is shown in Figure 6 and examples of single scans are shown in Figure 7. Note the calibration signals generated by internal sources which allow quantitative estimation of experimental signal levels. Eight channels of imagery taken at Santa Barbara are shown in Figures 8 and 9. It can be seen that the lighter tones of the oil slick in the ultraviolet (0.32 to 0.38μ) become darker in the 0.8 to 1.0 microns channel decreasing the contrast. Careful densitometric measurements on imagery such as this provide a reflectance spectrum which has the potential of being identified as that of oil and possibly even the type of oil. Some idea of the discriminating ability may be

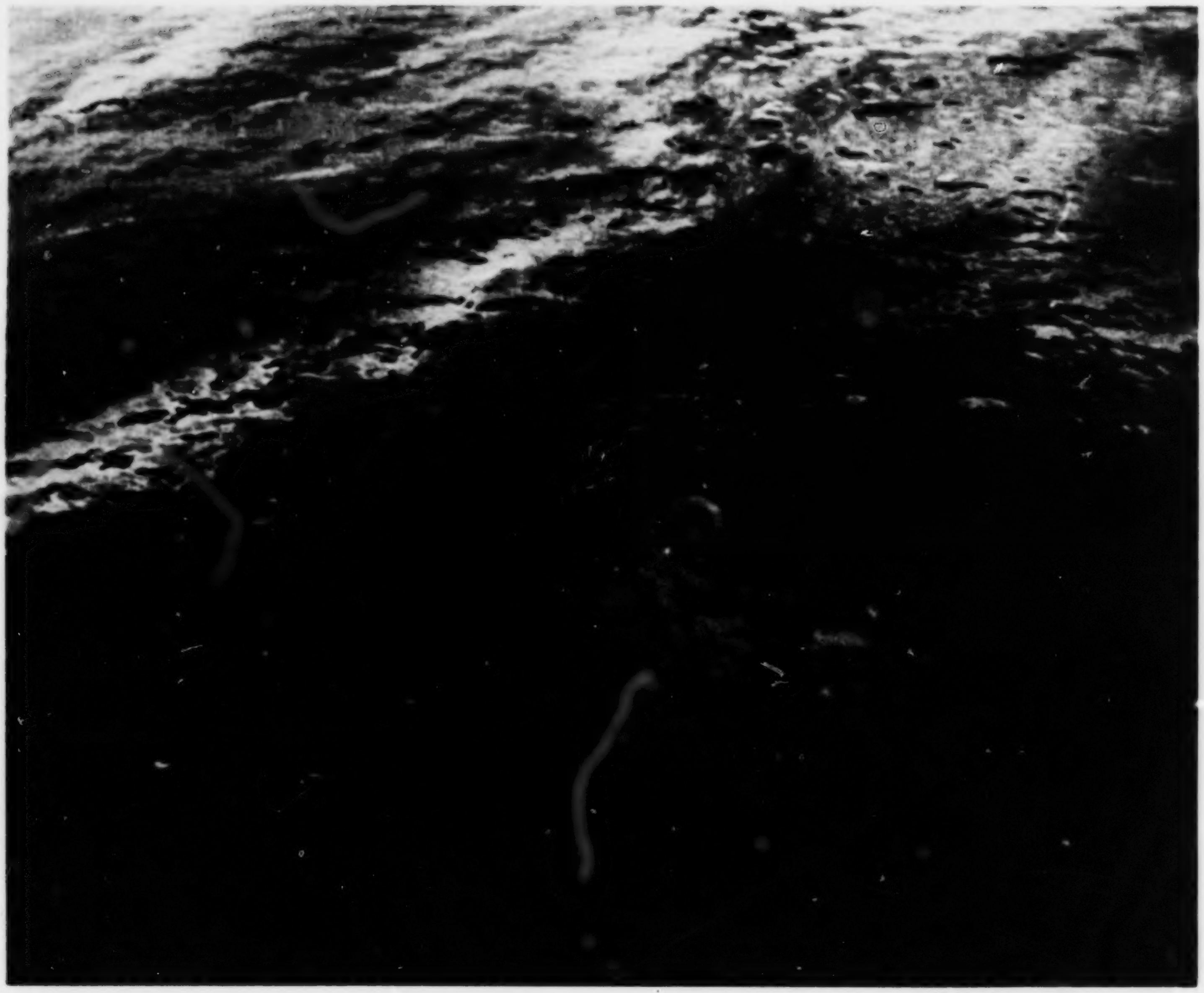

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Figure 4. Natural color photograph taken over Santa Barbara. Interference fringes may be seen indicating the presence of thin films.

obtained from Figures 10 and 11. In Figure 10, the oil slick reflectance in the U.V. is contrasted with the absence of significant differential reflectance in the solar infrared. In Figure 11, the lower reflectance in the U.V. of kelp compared with water is contrasted with the exact opposite effect in the solar infrared. It is possible to implement such recognition techniques by on-line data handling systems when electronic multispectral scanners are used.[5] In fact, this is a major advantage of scanners.

In the longer wavelength regions from 3 microns to .8 meters, the detected radiation is that emitted from all objects which are at temperatures above 0° absolute.

In the infrared region, the total radiated power from a black body (ideal radiator) is given as $W = E\sigma T^4$ where σ is the Stefan-Boltzmann constant, T is the absolute temperature, W is the emitted power and E is the emissivity which for a black body has a value of 1. An infrared sensor (or radiometer) measures the emittance (energy emitted per unit area) from the scene elements. These measurements are interpreted as apparent surface temperatures of those elements, by assuming black body emissivity. Because all natural objects have emissivities less than 1, the apparent infrared radiometric temperatures will always be less than the thermometric temperature. In any case, contrast between target and background results from differences in emittance.

Infrared scans may be processed to provide imagery as illustrated in Figure 12 which was taken at night over Santa Barbara. The dark areas represent portions of the oil slick having apparent temperatures less than the surrounding water. The interior regions of the slick appear bright, indicating a higher apparent temperature. The explanation for this is not presently known. Either differences in emissivities, differences in local temperatures or both may be the cause. The evaporation process or heat conduction anomalies could result in temperature differences which depend on film thickness.

The relationship of emissivity to film thickness is presently being investigated.[6] The North American Rockwell group 7 made measurements on a 7.5 gallon dump to determine the variation in total emittance with thickness. Microdensitometer tracing of the IR imagery provided an isodensity trace, Figure 13, which was related to the thickness as shown in the figure. Thus, microdensitometry of IR imagery or on-the-line processing of individual scans may yield satisfactory film thickness measurements.

Like the infrared sensors, microwave radiometers respond to total emittance which, in turn, depends upon the emissivity and temperature of the body of interest. In this region, emittance is related to temperature by the expression $W = E\,T$. Assuming that E has a value of 1, the emittance provides a direct measure of T, which is referred to as brightness temperature. Differences in brightness temperature result in changes in the radiometer voltage output which may be converted to an image in the same manner as the IR signals. It is known that the state of polarization of the emitted radiation varies with look angle. As a result, it is common practice to separately measure brightness temperatures from both vertically polarized and horizontally polarized radiation. In general, the vertically polarized emission is larger than the horizontally polarized.[2] Here, as in other methods, differences in the sensed parameter allow detection.

Figure 14 shows a microwave response curve compared with an IR microdensitometer trace of the same flight path. The microwave response indicates greater brightness temperature in those regions showing cooler temperatures in the IR region. Measurements made from a causeway revealed a similar picture. The distinct difference between the IR and microwave is at first startling; however, emissivities in these two regions may be quite different accounting for the opposite results..

As in the IR, film thickness apparently has an effect on the emittance. Aerojet General[8] has performed laboratory measurements along these lines. At present, it appears that the microwave region offers little possibility for identification but has definite potential for detection and thickness measurements.[8, 9]

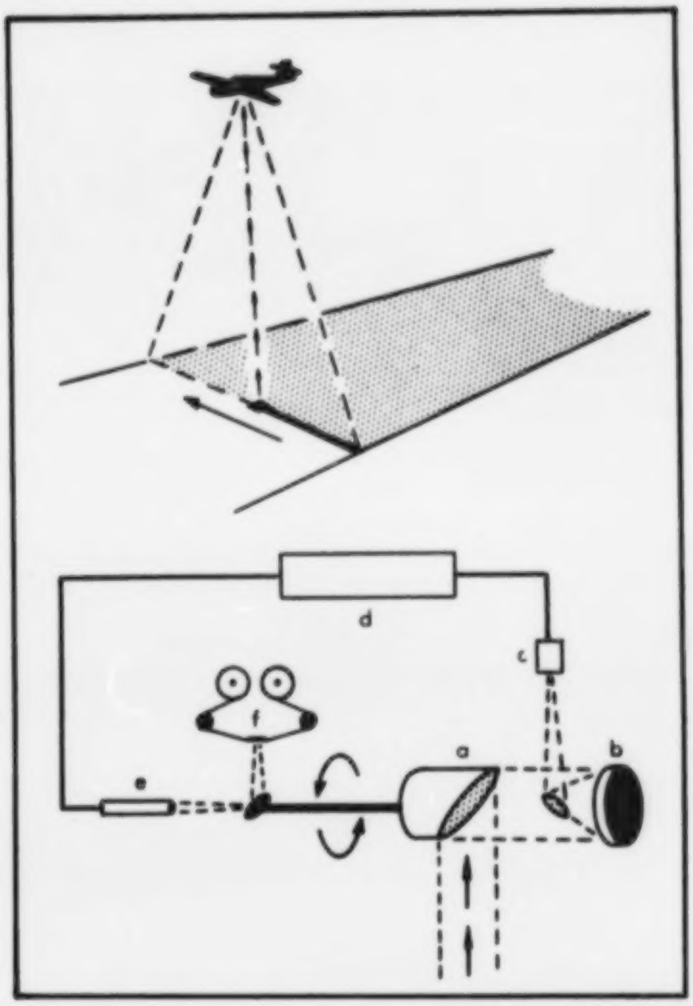

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Figure 5. The top figure illustrates the scanning procedure and the bottom figure illustrates a basic scanner. In the bottom figure (a) is a rotating mirror, (b) is a concave mirror, (c) is an electronic detector, (d) an amplifier, (e) a light source modulated by the amplifier output, and (f) is photographic film for image registration.

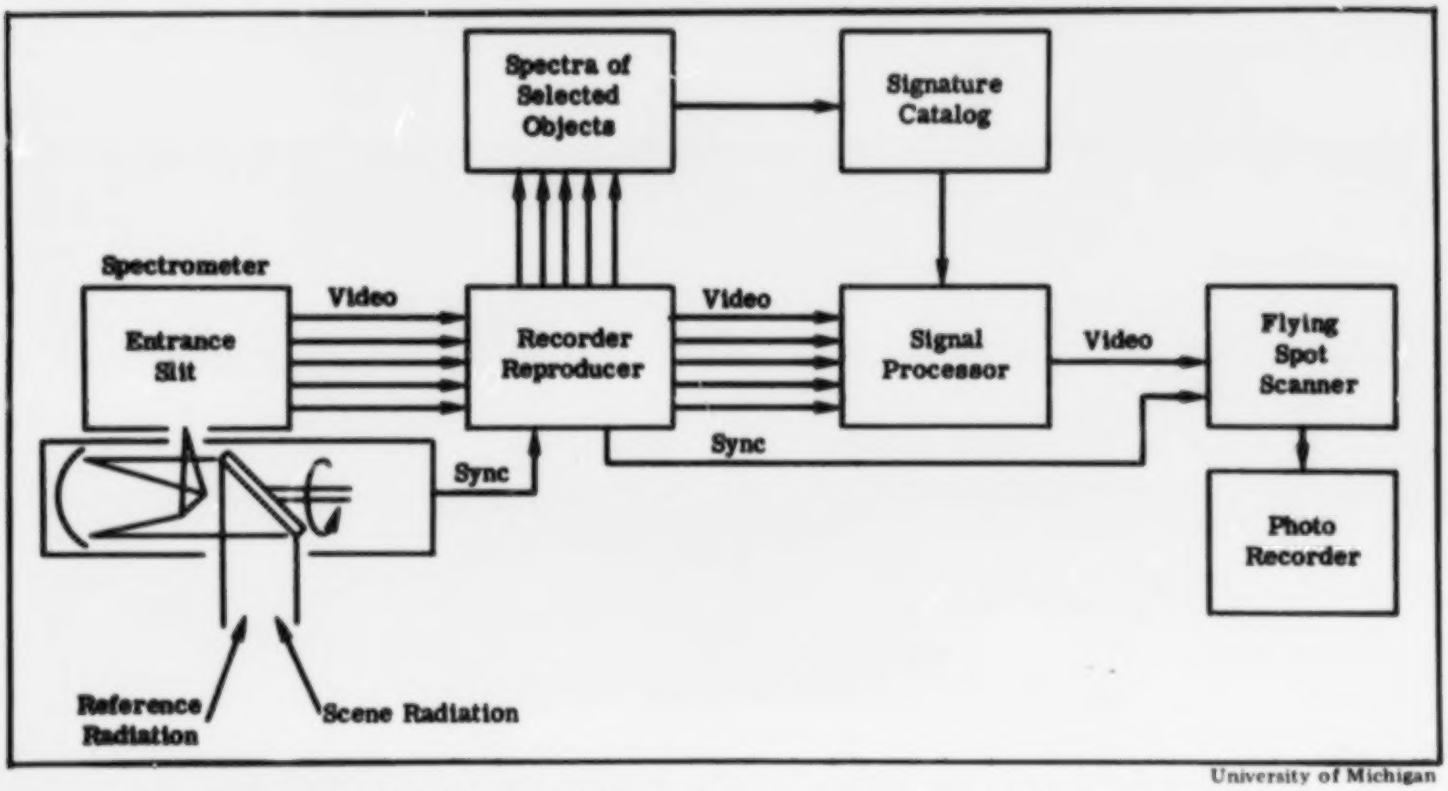

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Figure 6. A schematic of the University of Michigan multispectral scanner and associated data processing equipment.

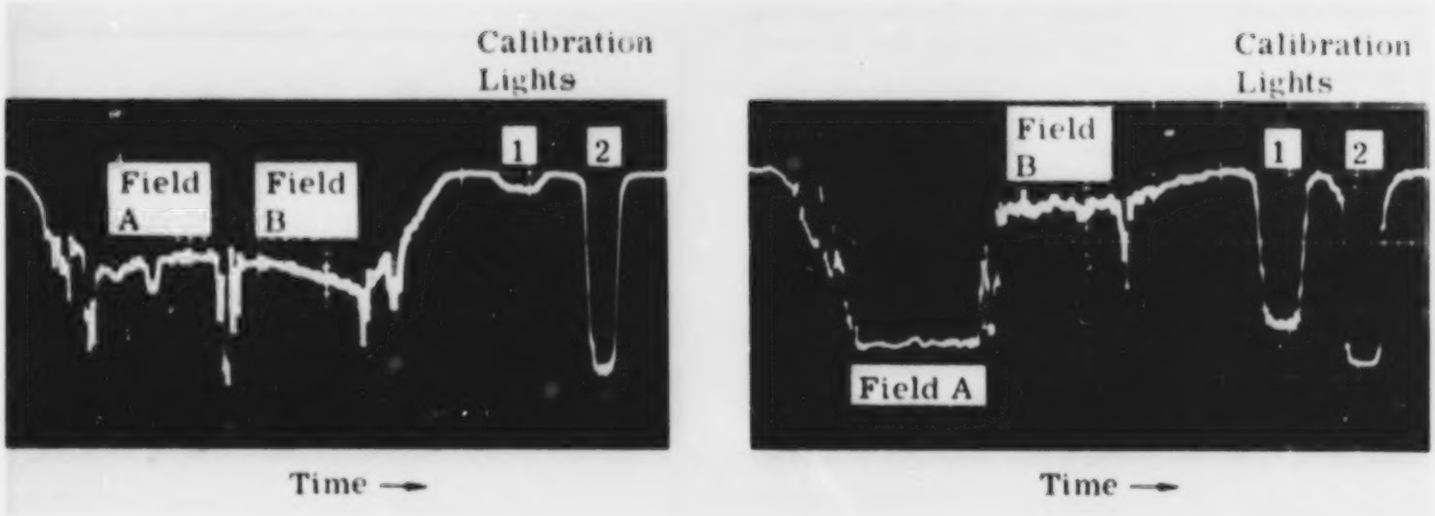

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Figure 7. Single scans from a multispectral scanner. Internal sources supply calibration signals (1 and 2). Field A and field B have different spectral characteristics. Typical spectrometer video data (U). California Rice Fields 5/26/66 at 1400 hours.

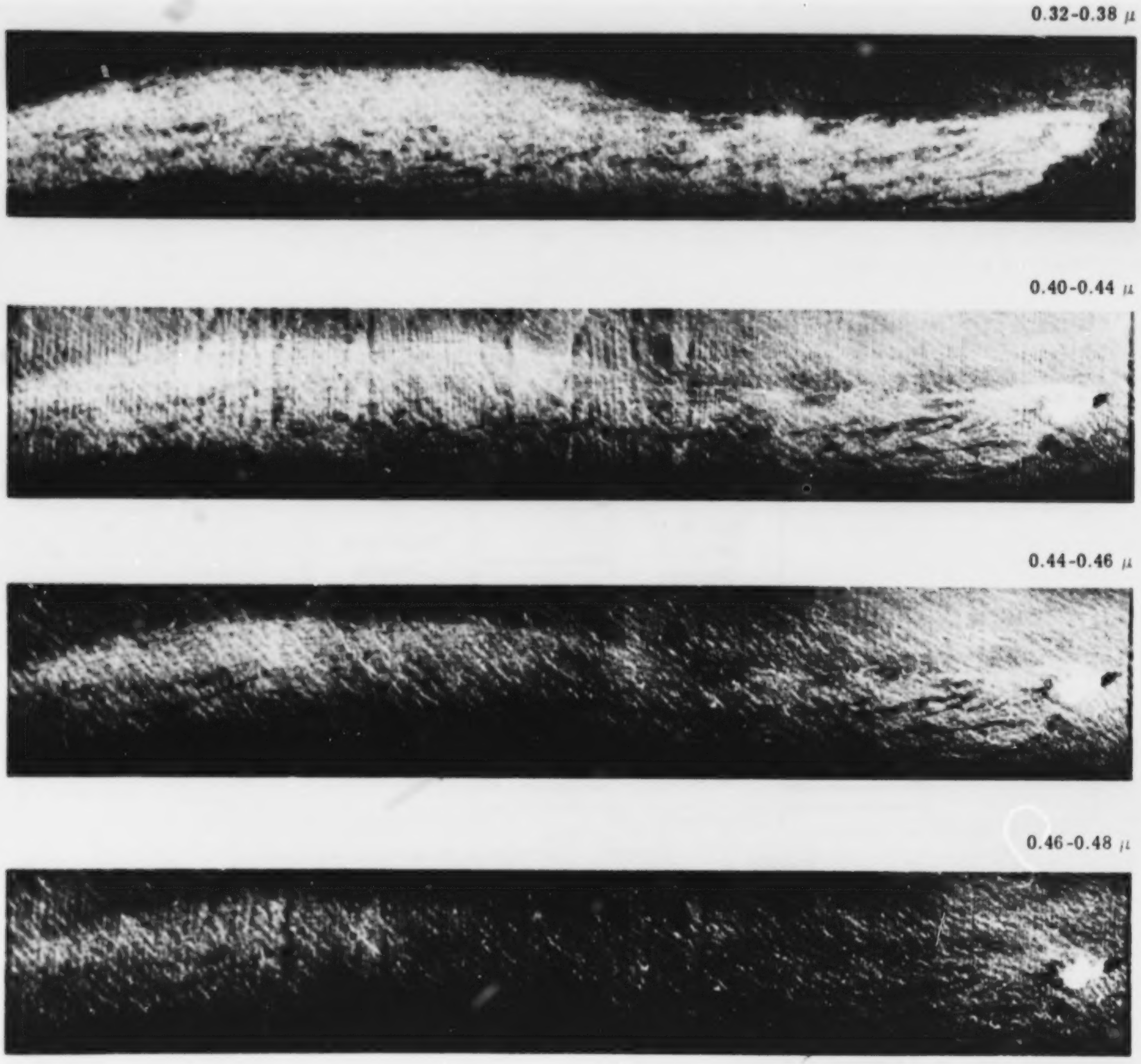

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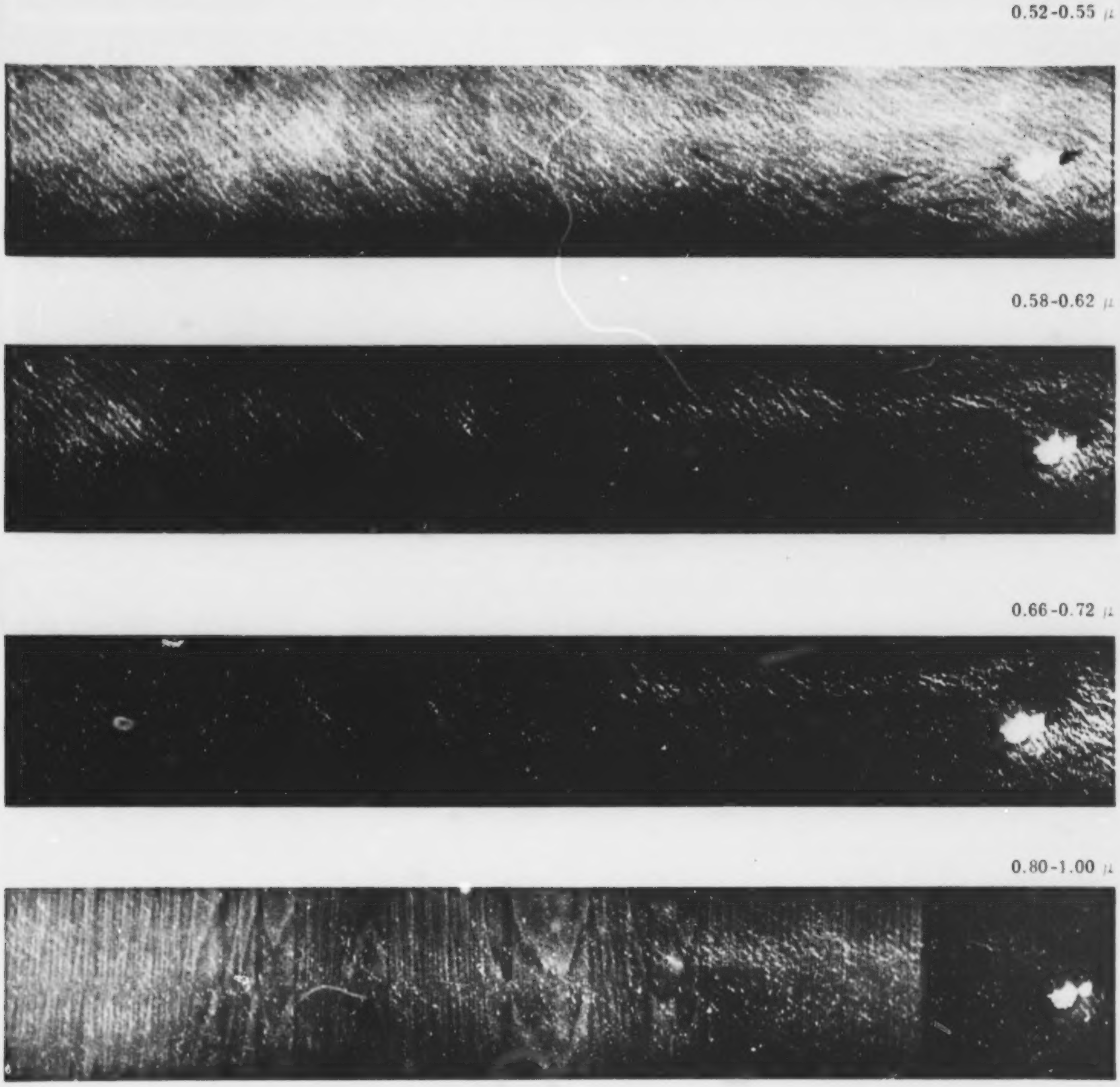
Figure 8. Four channels of University of Michigan multispectral imagery. The spectral range is from 0.32 to 0.68 microns. Note decreasing contrast from top to bottom.


0.52-0.55 μ

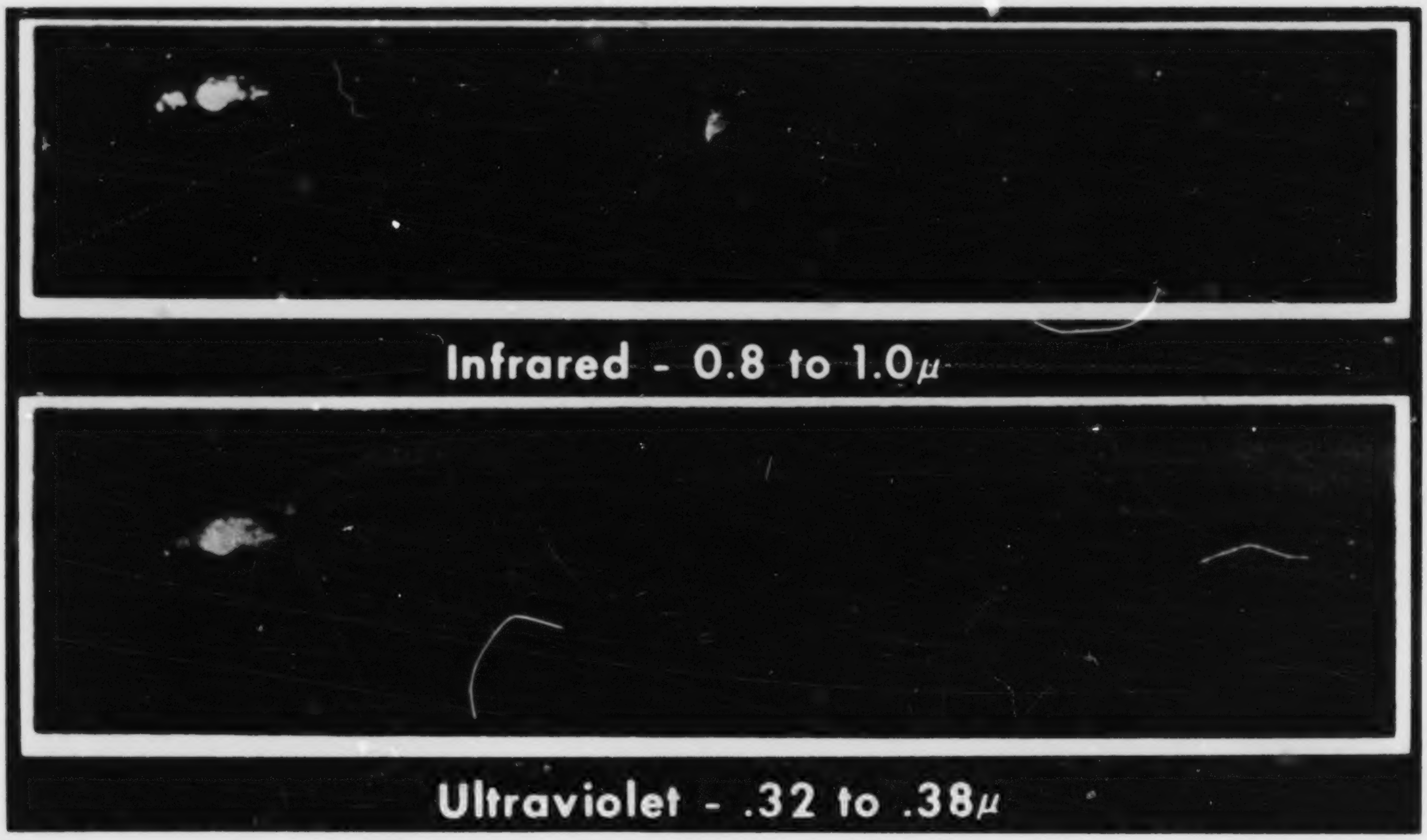
0.58-0.62 μ

0.66-0.72 μ

0.80-1.00 μ

University of Michigan

Figure 9. Four channels of University of Michigan multispectral imagery. The spectral range is from 0.52 to 1.00 microns. It is almost impossible to detect oil film in this set.



University of Michigan

Figure 10. Two channels of imagery with oil on the surface. In the solar infrared at the top no trace of oil is seen, while in the U.V. at the bottom, the oil shows up clearly.

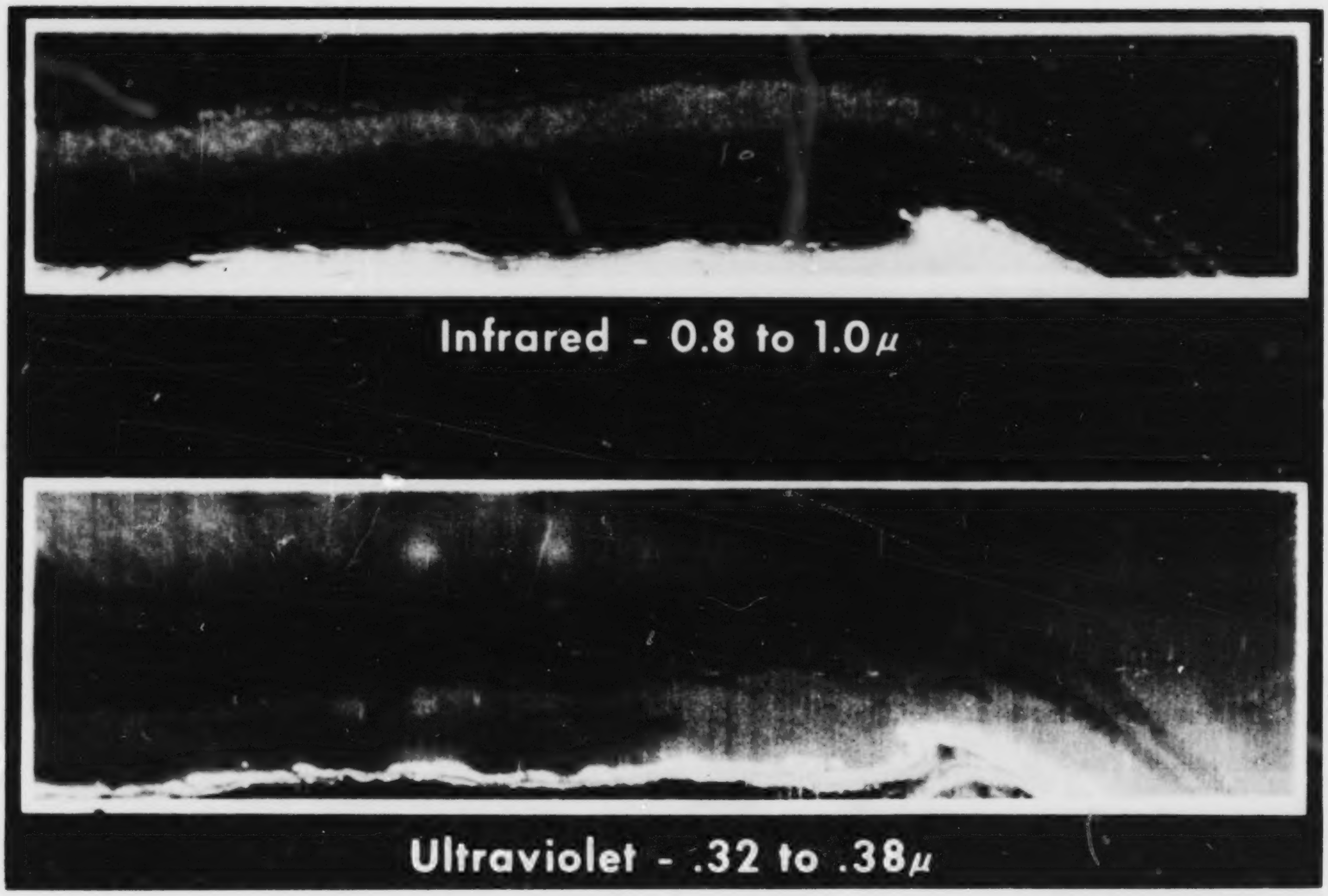


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Figure 11. Two channels showing fronding kelp. In contrast to oil the kelp is highly reflective in the solar infrared and absorbing in the U.V.

Another passive method which appears to have potential but has not been field tested in oil slick detection is the Fraunhofer Line Discriminator, used to sense solar stimulated fluorescence. Many substances, including oils, absorb light particularly in the ultraviolet region and re-emit this energy at longer wavelengths. The wavelengths of re-emission are uniquely determined by the emitting substance, as are the wavelengths absorbed. Unfortunately, the low intensity of the fluorescence is ordinarily masked by the high intensity solar radiation. The Fraunhofer Line Discriminator takes advantage of the fact that certain spectral lines are partially absorbed in the outer portions of the sun and appear at low intensities at the earth. These regions of low intensity allow detection of fluorescence at these wavelengths even in the background of high overall solar intensity. Hemphill[10] of the U.S. Geological Survey is doing work in this area and it should soon become available for field trials.

Active Methods

Active methods in which the source of radiation is an integral part of the instrumentation, as in radar, have not been directly investigated for use in oil spill detection and identification. However, it is expected that some experiments will be conducted in the near future.

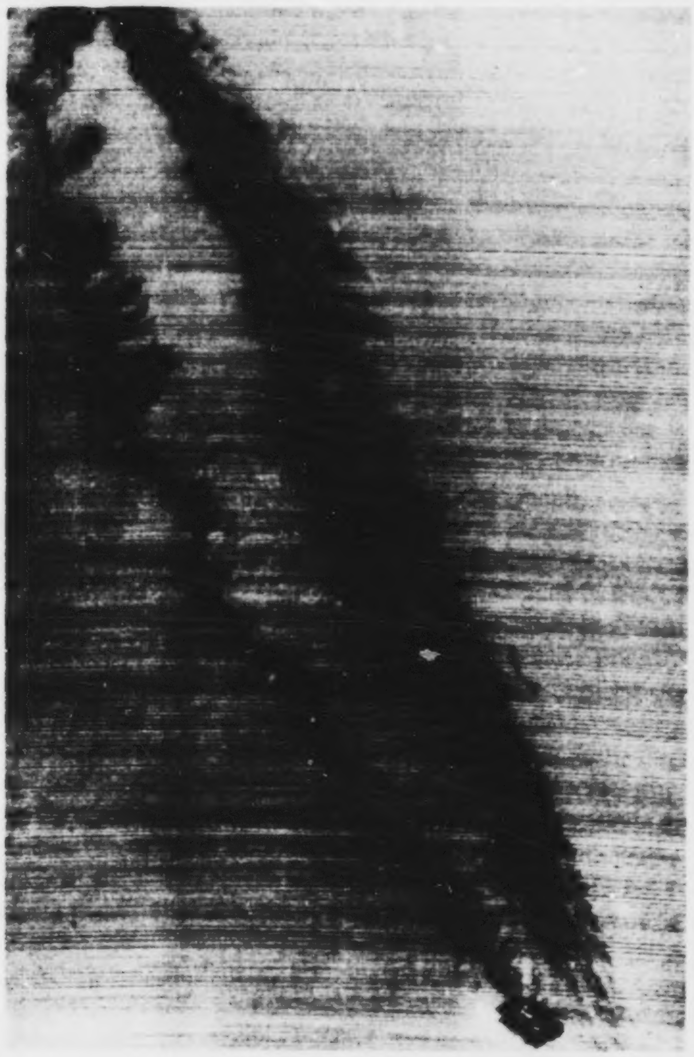

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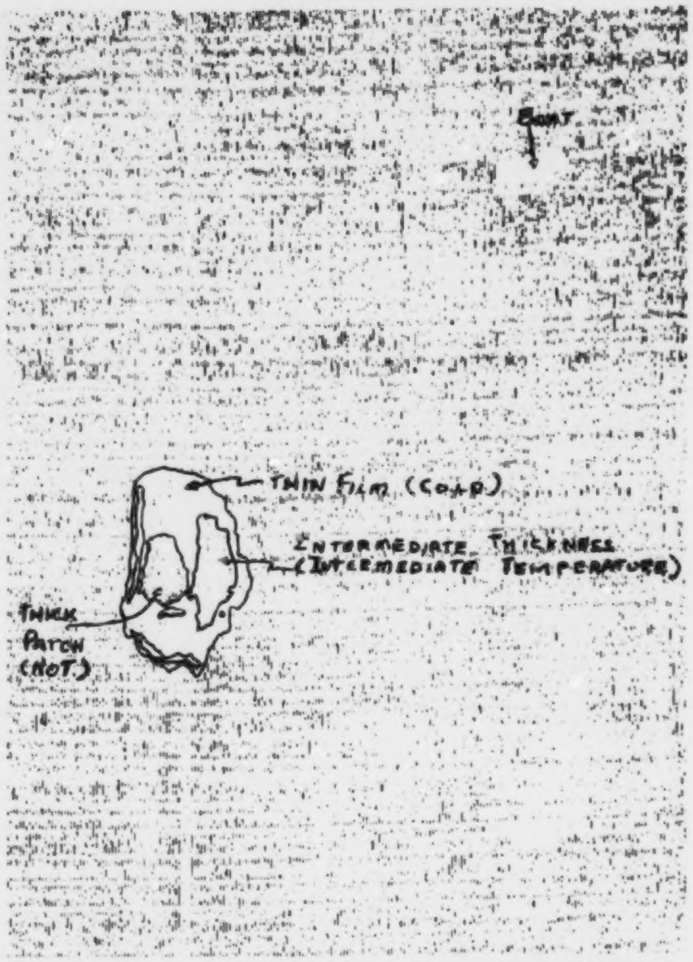
Figure 12. Infrared night-time image (8-13 μ band) taken over Santa Barbara, Platform A, March 27, 1969. Note scan lines due to infrared scanner. Dark areas are thin edges of the oil while the lighter area, between these edges, is due to thick body of oil.



North American Rockwell Corp.

Figure 13. Microdensitometer tracing of infrared imagery of a 7.5 gallon oil dump off Coal Oil Point on March 24, 1969. Lines indicate isodensity contours separating thin areas from thick areas. On original imagery the thin areas are dark and the thick areas are light.

The use of lasers in a radar like configuration is also being investigated. Laser stimulated fluorescence may be sufficiently intense to detect material at night and possibly even in the presence of sunlight.

Conclusions

All methods investigated so far have the ability to detect the presence of a surface film. However, the potential for positive identification of the film substance appears to be offered by multispectral methods only. Unfortunately, the methods (U.V. through IR) by which spectral signatures are detectable become inoperable at night and/or in bad weather. On the other hand, microwave methods possessing all weather capability do not allow spectral differentiation. It may be that other recognition techniques are possible but if so they have yet to be worked out.

A more complete picture of remote sensing of oil spills will emerge after active and fluorescence detection methods have been fully investigated. These sensors will most likely have the capability of detecting and monitoring surface films but not of identifying the contents of the films. Nevertheless, we will have a choice of sensors useful under a variety of situations for detecting films with identification reserved for the laboratory.

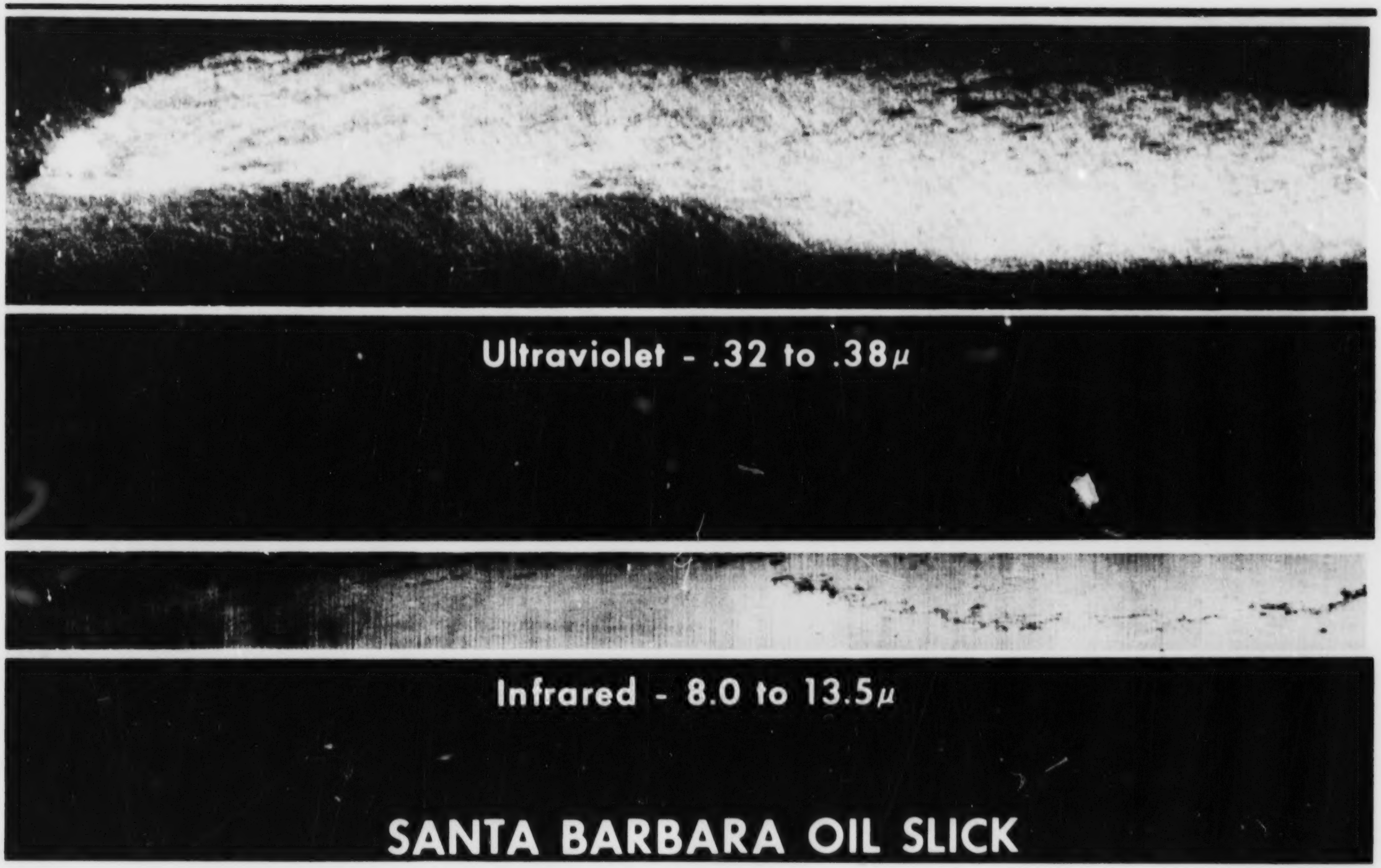


Figure 15. Compares scene taken in the U.V. to the same scene in the thermal infrared.

University of Michigan

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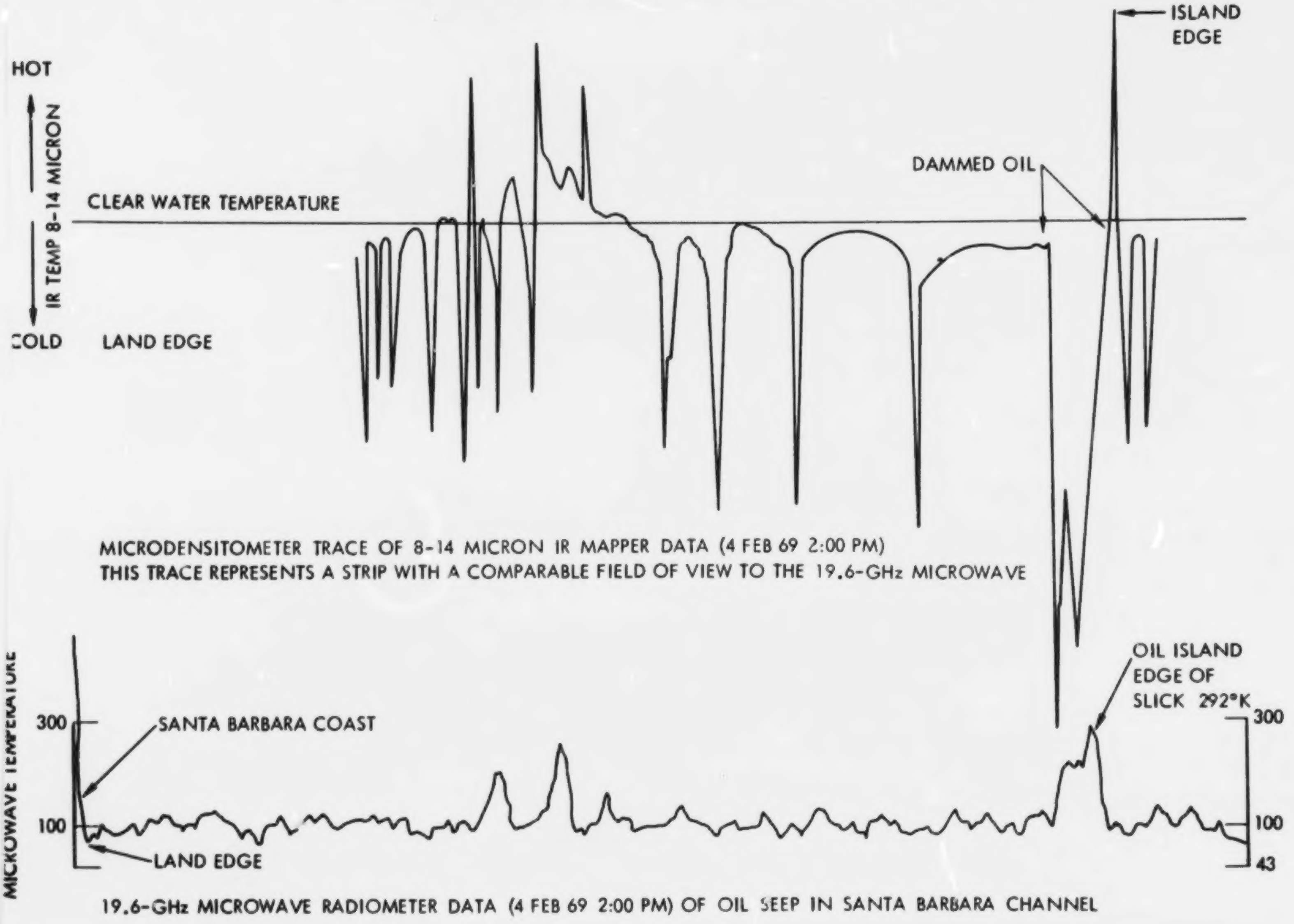

North American Rockwell Corp.

Figure 14. Comparison of microwave and infrared measurements along the same flight path of the Santa Barbara spill. Slick edge images as hot in microwave and cold in infrared. Differences between these data are not yet understood.

The Santa Barbara Study

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Abstract

This paper gives an outline of the unique problems associated with determining the effects of the oil spill in the Santa Barbara Channel and a general outline of biological studies associated with the spill.

The blowout at the Union Oil Well Platform A occurred on January 28, 1969. While flow from the well was stopped within three weeks of the mishap, oil still continues to leak from the area around the well. Present estimates of seepage are around 400 gallons per day. Estimates of seepage from the Coal Oil Point area are around 900 gallons per day. While this means that the man-made seepage is at present only adding a relatively small amount to the volume of natural seepage in the area, it is releasing oil which is intermittently polluting beaches.

The well is located 3 miles offshore from Santa Barbara (Figure 1). Data supplied by the Coast Guard showed that most of the mainland shores of the Santa Barbara Channel and some areas of the Channel Islands were effected by oil by March 31. By the end of July, there was no mainland beach in the Santa Barbara Channel which was uneffected by oil. While the distribution of the oil on the beaches varied, it tended to accumulate in the upper littoral zone.

Prior to the Santa Barbara spill, the *Torrey Canyon* wreck and the *Tampico* wreck were the most publicized oil spills. These differed from the present spill in that the vessels were carrying crude and diesel oil respectively and in both cases the oil was released over a relatively short period of time compared with the Santa Barbara spill. The *Torrey Canyon* spill effected large areas of the shores of England, Wales and France while the *Tampico* spill was confined to a small bay. The *Torrey Canyon* spill was heavily treated with detergents while detergent use was negligible in the Santa Barbara Channel.

There are several other factors that are unique to the Santa Barbara Channel:

1. The long history of natural oil seepage in the area.
2. Unusually heavy winter runoff at the time of the spill which reduced salinities, increased sedimentation, and increased DDT in the channel.

Natural oil seeps have occurred in the Santa Barbara area throughout recent and geological history. During this period it is possible that the fauna in the area has developed some immunity to continuous exposure to low concentrations of oil. In the Coal Oil Point area where there is the largest concentration of oil seeps, there is no dearth of animals in the intertidal area. Divers have also observed *Diopatra* (Annelid), Nudibranchs, several species of fish, starfish, all living in areas of natural seepage.

The flow from these natural seeps is variable and activity may fluctuate rapidly during the day. After the heavy runoff in January, February there was an increase in natural seepage in the area. For example, tar mounds have been known to exist off Carpinteria Beach but no seepage had been observed in this area over recent years. Seeps were again active in this area over the March-June period of this year.

Unfortunately, little data is available on salinity changes caused by the heavy winter runoff. However, workers from Santa Barbara noted high mortality among sedentary intertidal species near the mouth of streams. Oil then came ashore and many hasty and untrained observers attributed

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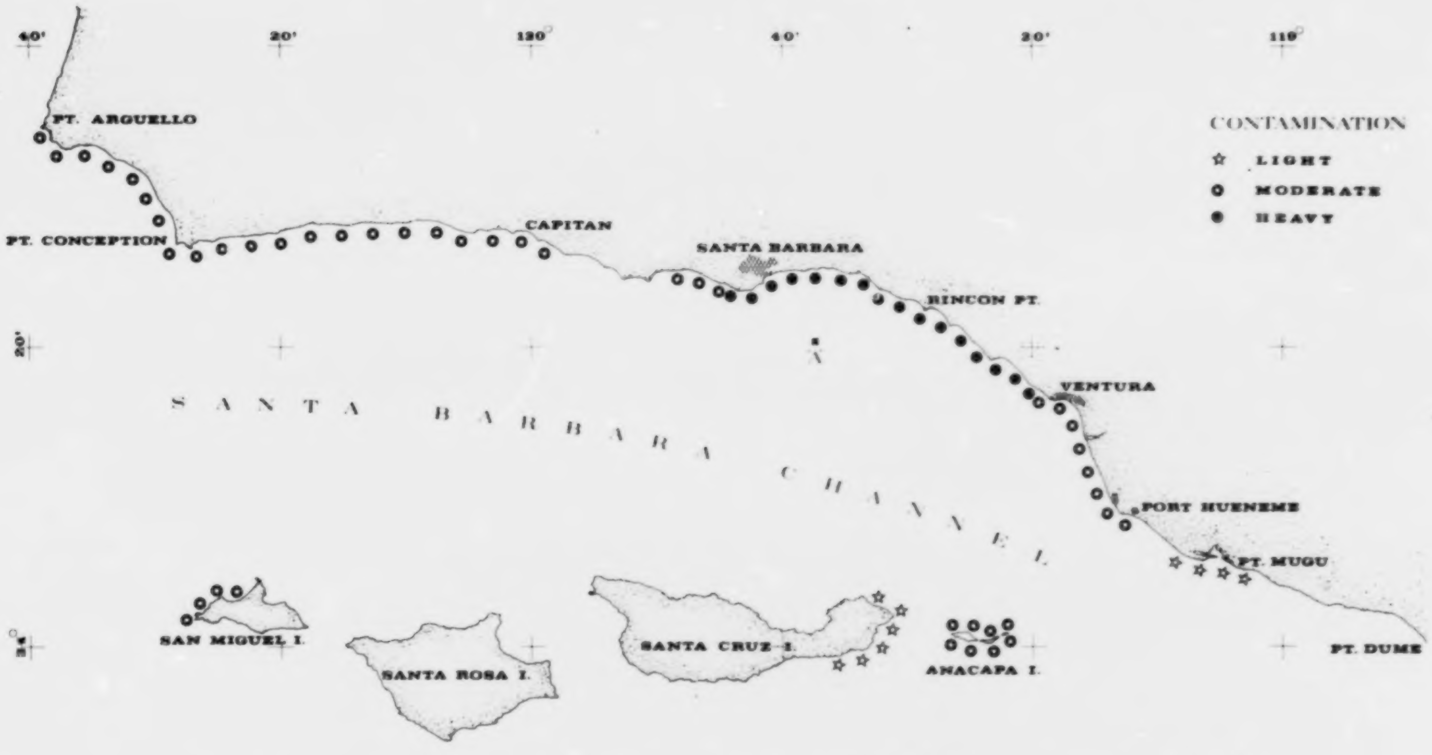

Figure 1. Area contaminated with oil from Platform A by March 30, 1969. (Data supplied by Coast Guard)

this mortality to the oil. Virtually no data is available on the change in pesticide levels in the Santa Barbara Channel. The rain occurred immediately after the citrus orchards were sprayed. As large quantities of oranges and other citrus debris were washed into the sea, most of these chemicals would have been washed seawards.

Soon after the spill both Federal and state authorities were active in the area. Several Federal authorities produced reports, which regretably, have not been released. U. S. Fish and Wildlife Service and California State Fish and Game have made cruises in the area. The former found that the plankton contained fish eggs and larvae of normal abundance and species. Phytoplankton counts were significantly lower than at a nearby station in January. The California State Fish and Game cruises recorded no significant changes in benthic and pelagic fish in the Santa Barbara Channel.

In mid February, the Western Oil and Gas Association granted the Allan Hancock Foundation $220,000 to study the biological and oceanographic effects of oil spillage in the Santa Barbara Channel following the 1969 blowout. At the time when the grant was received, all were optimistic that the flow of oil would be stopped and that over this period, we would obtain data on the recovery of the area.

The overall study can be divided up as follows:

1. Biology
   a. Phytoplankton productivity
   b. Zooplankton
   c. Benthic communities
   d. Intertidal and shallow water algal and invertebrate studies
2. Geology and Oceanography
   a. Planktonic, benthic and intertidal foraminifera
   b. Water Chemistry
   c. Geology and Oceanography
3. Bacteriology
   a. Effects of oil and benthic bacteria
   b. Effects of oil on sewage outfall

I shall only discuss the biological section of the program. Dr. Kolpack will discuss part of the geology and oceanography work. Briefly, the bacteriological work involves a study of changes in the bacterial population in areas of the oil spill and a study to determine if there are any changes in the bacterial population of sewage outflow in the presence of an oil slick. The oil slick cuts down the penetration of UV light and this could effect the bacterial population in the latter case.

Following the oil spill, the damage was most obvious in the intertidal zone and to the bird population. The Department of Fish and Game estimated the loss of birds due to the oil spill to be 3,600 by the end of March. This did not include birds which perished on the open water and failed to drift ashore. They also reported no influx or exodus of birds from the area but most birds appeared to avoid oil contaminated areas.

Concern was also expressed for the large marine mammals. The Grey Whales migrated north during this period and strandings were not higher than those reported in previous years. Autopsies on carcasses of stranded whales and seals failed to reveal the cause of death. Mortality data for the seal colony on San Miguel is not available for years prior to the oil spill. Hence, it is not possible to determine changes in mortalities in these colonies.

Intertidal rocky-shore transects were established at intervals along the southern California coast by Yale Dawson ten years ago. These were resurveyed by Mike Neushal and others from the University of California, Santa Barbara to determine the immediate effects of the oil spill on the intertidal areas. The work on the present grant overlaps with, and continues on from Neushals work. It is planned to continue these surveys after February 1970 to obtain long term recovery data. In general, where the oil has been lost from rocky substrates, recolonization has commenced.

The macrofauna on several sandy beaches are also being studied. The lack of background data, and the large seasonal and short term changes in the amount of sand on the beaches makes the effects of oil on sandy beach fauna difficult to assess. At present, there is a layer of oily sand on many beaches several feet below the surface. The macrofauna lives above this oily layer. With the onset of winter storms this oily layer will again be exposed and it will be interesting to see whether the animals avoid the oily sand or if the oil is now degraded to an extent so that it does not effect them.

The effects on the planktonic, benthic and pelagic species are less visible. The commercial fishing industry immediately started to report smaller fish catches. Fish catch data is being supplied by California Fish and Game while the Bureau of Commercial Fisheries is providing fish spotting data. Fish catch data is dependent on the willingness of fishermen to use their boats and equipment in oil water. Fish spotting data is considered to be 95% accurate. The oil in the Channel in February made it difficult to spot any fish; subsequent to this, the Pacific Mackerel (tons/flight) was more plentiful than in the previous two years while anchovys were more plentiful than in 1968 but available in similar quantities to 1967. Pacific Bonita which is normally absent in April, May and June, was not recorded from the Channel between February and July of 1969.

Benthic communities were intensively sampled in the Santa Barbara area between 1956 and 1959. This survey is providing background data for the present study. Samples are still being sorted and until this is complete, it is impossible to even guess at the causes of changes in the fauna. The zooplankton samples are also being analyzed. In this case, background data is available from these stations in the Santa Barbara Channel regularly sampled on CALCOFI cruises. There is no background data available for the phytoplankton productivity study. Indications to date suggest that phytoplankton productivity is not significantly effected by an oil slick.

The present study is still far from complete. As mentioned before, the emphasis is still on obtaining field data and, as a result, there is a lag in compiling results and drawing definite conclusions. The final report is planned for publication in September of 1970.

Some Ecological Effects Of Marine Oil Pollution

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Abstract

Oil at sea affects chiefly species associated with the surface; damage at sea by oil and dispersants after Torrey Canyon *were not as bad as expected.*

Slicks sometimes disappear naturally, how apart from physical actions may this be taking place? Bacteria can, under experimental conditions very favorable to their growth, assist in dispersal, sinking and decomposition of oil, and zooplankton can ingest oil droplets, but are these factors of significance at sea?

On shores after Torrey Canyon, *far more damage was done by excess detergent than by oil. Repopulation is following the expected sequence, most affected shores being still abnormal. Observations on oil left untreated in Cornwall, at Eleuthera and on the Devon coast show slow removal by various natural means, including the browsing action of fauna.*

Toxic detergents can affect the sublittoral zone, including species of economic importance. Areas liable to repeated pollution, such as estuaries and salt marshes, require special care. The use of newer dispersants of low toxicity is desirable here and on shores.

On The Open Sea

The organisms affected are those connected with the extreme sea surface. Birds show the most conspicuous and serious damage, and round the British coasts the slow-breeding awks are perhaps the worst hit; the subject is too complex to enlarge on here. It is well reviewed by Clark.[1]

Subsurface plankton collected after *Torrey Canyon* by the M.B.A. Ship showed damage to minute plant cells of the order Prasinophyceae which float at the surface. Eggs of pilchard also float; they showed a high proportion dead and there was a local shortage of pilchard larvae. This damage could have been from the toxic fractions of the crude oil or from the toxic solvent of the dispersants before they evaporated. Damage to mid-water forms was not detected after *Torrey Canyon*, nor even tainting of fish caught below a slick; in fact, at sea, effects of that major spill were not nearly as bad as expected. There seem to be misconceptions about this, probably due to press reports confusing damage by dispersants on shore and close in-shore with effects on open sea. A single catastrophic spill at sea is quite different from the often serious effects of chronic oil pollution in fairly enclosed waters.

At sea, slicks sometimes disappear naturally and one very much wants to understand the processes by which this can happen to assess how artificial aids, if and when applied, fit in with the natural processes. Obviously, physical factors, evaporation, spreading or alternative "mousse" (water-in-oil emulsion) formation and breaking up of slicks are of major importance. Photochemical oxidation is a possible means of actual decomposition of oil. Dr. ZoBell,[2] Gunkel, and others have shown that bacteria, under certain conditions, can help in dispersal and sinking of oil, as well as in its decomposition. I too have recently made observations which confirm this under enriched conditions in the laboratory.

What happens on the under side of an oil slick at sea? Experiments with slicks on open water are essential because laboratory conditons are so different from those at sea. To what extent are separate droplets formed by natural processes? This is of major importance in connection with suggestions which have been made concerning the possible uptake of oil by zooplankton. I myself have seen that it is

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[1] Superior numbers refer to literature references at conclusion of text.

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possible for the large copepod, Calanus, to ingest oil droplets from artificial suspensions and this has been clearly demonstrated by Admiralty Materials Laboratory workers on some other zooplankton species (as yet unpublished). Any analysis of oil in zooplankton must clearly distinguish between mineral oils and biological oil reserves common in copepods, fish, etc. One must remember that copepods are by no means little automatic filtering machines; some, at least, are quite selective feeders and their appetites vary according to the time of year. Moreover, they undergo diurnal vertical migrations spending only part, if any, of their time very near the surface. Only just below the surface are the numbers of oil droplets likely to be perhaps of the same order or frequency as phytoplankton cells, but obviously both are very variable members.

Admiralty Materials Laboratory analyzed some samples of apparently clear water taken near slicks after *Torrey Canyon* and found in the surface samples 7-14 parts per thousand million of oil as compared with a "normal level" in English Channel waters of about 3 parts per thousand million. Oil was not detectable at subsurface depths (see Smith p. 34).[3]

The uptake of oil by zooplankton is being investigated in Britain because it could be the route by which oil products could enter the food chain. Copepods pass material through their guts rapidly; while some lighter fractions might diffuse through gut membranes, it seems very doubtful if mineral oils would be digested. Possibly oil droplets in faecal pellets might be in a more favorable position for bacterial attack while the pellets are sinking. During the diurnal migration of zooplankton, ingested oil could be carried down to deeper layers thus making a further small contribution to oil dispersal.

During weathering, the lighter fractions (some of which cause immediate acute toxic effects) have been evaporated or perhaps dissolved away. That weathered droplets seem to be fairly innocuous material, is suggested by the fact that thriving cultures of minute flagelles and ciliates (10-25 microns long) have often been found in my oily brews with numerous oil droplets (down to 1 micron diameter) in their food vacuoles, i.e., in very close contact with their protoplasm. This does not, however, mean that they are deriving nutriment directly from the oil but much more likely, they are feeding on associated bacteria, and they would later reject the oil as do many other larger animals. There could, however, be potentially toxic substances among the heavier ends as well, which could be accumulated via a food chain.

These observations are intended simply to show some of the ecological possibilities which have to be considered when discussing the fate of oil at sea. A great deal of further work is required on the many aspects of the subject.

On The Shore

First, one must distinguish between main types of beach pollutants. Chronic pollution, in which lumps of oil are stranded, has considerable nuisance value, but these lumps are of little consequence ecologically, so far as we have observed. Dennis[4], in his survey of the Atlantic coast of the States, deduced that coccina (small lumps of hardened oil often mixed with sand) must be abraided away by natural forces or they would accumulate more than they do. On the British coast, we have sufficient of this type of pollution on amenity beaches for some local authorities to think it worth while to collect and dump it. Dispersant treatment of this type of oil is a waste of time and money and could do considerable harm ecologically.

Catastrophic spills and lesser ones of fluid oil present altogether different problems. On amenity beaches it is acknowledged that they must be cleaned up because natural processes of removal are generally far too slow. We favor the use of mechanical means first, followed by the controlled use of dispersants where necessary, and would seek the use of the new types which have both low toxicity and reasonable efficiency.

On Sands

On the sandy parts of Cornish, shore oil soon became buried by wave-deposited clean sand and layers of oily sand underwent biodegradation with the production of grey sulphide layers; but, unless the oily sand layers were broken up, bacterial action was very slow. Treatment was mechanical and combined with the use of dispersant. Gunkel[5] recorded very high numbers of oil degrading bacteria on contaminated Cornish beaches. He also showed experimentally that the few bacteria which were able to survive the toxic dispersants, were then able to thrive on their kerosene extract solvents. A visual demonstration of this is seen in a jar containing 2 ml/litre of kerosene extract in nutrient sea water. Bacterial growth is obvious.

On the remote coral sand beach at Eleuthera (Bahamas), layers of buried oil from the General Colocotronis spill (March 1968) are seen. The beach was obviously very labile, so we thought that the porous sand particles would themselves act as dispersal agents for the oil and it was far better to leave such oil as had stranded to be dispersed and decomposed by natural agencies. Unfortunately, I have not been able to obtain any later reports on that beach.

Of oil spills on stable sands or muds on less exposed coasts, I have no personal experience. Such beach material contains a far richer fauna than does sand with low silt and organic content and it would seem all too likely that the infauna could be seriously affected by layers of oil.

On Rocky Shores

We have been collecting information on the biological changes and the fate of the oil itself, left untreated on rocky shores. Various physical factors are obviously very important: (1) the type and thickness of the oil, (2) the latitude, climate and time of year having their effects chiefly through viscosity differences, and (3) the exposure of the habitat to wave and sand abrasion.

The toxicity of the oil itself is sometimes considerable, sometimes not, according to its type and degree of weathering. There are various records of the toxic effects of fresh crude and of diesel oil. At the Tampico Maria spill, so well followed by North, Neushul and Clendenning[6], the heavy diesel oil was emulsified by the surf and had serious lethal effects on the fauna. Because it killed browsers, it encouraged subsequent algal growth. There is incidentally much in the general pattern of their observations on repopulation which we have also seen on Cornish rocky shores; but here the damage was done by the toxic detergents used in excess, the Kuwait crude oil itself, having been at sea for 10 days or so before stranding, had lost all the worst of its toxicity.

You may have heard of evidence that browsing fauna can play a part in cleaning off oil. On our temperate coasts, I consider it to be a small, but not insignificant activity of limpets, where, in the mid-tide zone, there has been a continuous cover of oil not so thick as to smother them completely. Cleared areas, tooth marks of oil and oily faeces show where they have been active and shell growth shows that the accidental uptake of oil has done them no harm–it is unlikely to have direct nutrient value. Patches of oil browsed away by limpets on a Brittany shore are seen in an area where no detergent was used but even after a year there was still much oil on the rocks. Spectacular removal of oil by chitons was seen at Eleuthera. Grey oily faeces of ground-up rock were common. (The animals have a continuous ribbon of teeth tipped with magnetite which enables them to erode the rock, in which process they obtain their normal food supply of algae which live within the porous surface.) About 50 per cent of the reef surface had been cleaned in about 15 days by chitons and nerites. Detergent treatment of oil on porous coral beach rock would have been most unwise, quite apart from killing off the useful fauna. Data recently published by Pearce and Ogren[7] on their observations on the San Juan spill (March 1968) and the conditions a year later indicate that where no cleaning was attempted there was little permanent damage except some areas of hard encrusted oil.

In October 1967, a spill of bunker oil landed as mousse only about 3 miles from the accident in Plymouth Sound, during a storm. We specially requested that some control areas be left untreated at Bovisand. The oil has been greatly reduced in thickness but even after 2 years the rocks at high tide level are still black with oil. At mid-tide level, browsing limpets and topshells have worked chiefly between the splodges of oil, leaving much of the oil untouched. A crust of fungal hyphae and algae seems to have protected the oil. This area lacked sand abrasion.

Effects Of Treatment By Toxic Detergents

Where detergents were used at Bovisand on rocks, much of it ran to waste because it does not readily penetrate "mousse." The ecological sequence so striking on the Cornish shores has been repeated here a year later. The changes extended well down the shore, below the oiled levels.

In Cornwall such was the zeal of the detergent cleaners (solvent emulsifiers) that very few oiled areas were left untouched. It must, however, be stressed that even in the affected 140 miles or so of Cornish coast, there were many undamaged sections from which recolonization took place. The most spectacular effect on these rocky shores was due to the killing of a high proportion of the browsing fauna, particularly limpets, which are both very vulnerable and also the most important herbivors of those shores. The removal of the grazers permitted the development of sporelings of algae. First there was a tremendously thick cover of green weed, chiefly *Enteromorpha* on the previously bare-looking rocks. The occasional surviving limpets were readily seen in bare areas a foot or so in diameter. By August young sporelings of brown fucoid algae were becoming numerous. They were better able to stand the exposed conditions. The brown weeds became so thick as to hinder the settlement of the usual fauna of mussels and barnacles for a time.

During the first winter the settlement of limpets began; this was of variable density on different shores. In some places they prevented any redevelopment of green weed, and usually there was no second settlement of fucoids. Where the limpets came back in force, they and the winkles made inroads on the fucoids, thinning out the small plants.

During the second summer and early autumn (1969), an abundant population of browsers had developed. Besides eating the fronds, radula marks could often be found on the stripes, thereby weakening the plant so that even if the stripe (or stalk) was not chewed right through, the frond could readily be torn away by wave action.

The rocks are now still heavily covered with seaweeds having a fauna under them more numerous and varied than before the detergent damage. It seems likely that in areas of moderate exposure, it will be several more years before anything like the original state is re-established. Places subjected to physical abrasion by shingle, etc., are passing through this ecological sequence more rapidly and already appear more or less back to normal, i.e., bare rock with fauna of limpets, winkles, barnacles and their predatory dogwhelks.

Such disturbances of shore habitats are certainly to be avoided in areas of special scientific interest, but detergent cleaning of rocks near amenity beaches can be accepted; providing it is done in limited amounts with careful washing away, preferably with sea water, there need really be very little damage. In the hands of workmen, dispersants of good efficiency and low toxicity are greatly to be preferred–such do exist now.

When man suddenly upsets nature on such a vast scale, complaints are rightly raised about it, especially when the long-term effects of the use of toxic material are unknown. The balance of shore life was upset and the rocks made dangerously slippery for several years, but it seems to me that though recovery is not yet complete, it is unlikely that any serious permanent damage will have occurred even after the colossal spillage experienced after the *Torrey Canyon* went aground. I would stress, however, that large amounts of oil could have been far more damaging in other areas. We hope that it was a once-only event to affect Cornish and Brittany shores, and that the drastic detergent treatment will never be repeated anywhere on such a scale. Because of the scale, the employment of inexperienced operators was unavoidable; and when one sees the difficulty of satisfactorily treating "mousse" with most dispersants, it is not in the least surprising that much of the older type toxic detergents ran to waste.

In Estuaries And On Salt Marshes

In areas liable to repeated spills, there is much greater need for care. At Milford Haven there are five recent oil refineries placed in an area of outstanding natural beauty. Oil spills are tackled at once on the water with dispersants and the area is remarkably clean for such a large oil port. Local hydrography with good flushing helps considerably. Occasionally, shores have to be cleaned but amounts of dispersant used are limited and carefully applied. Limpet kill has not been catastrophic, no phenomenal green phase has occurred, and the fauna has more or less recovered within a year. Nevertheless, there is anxiety about repeated oiling of the same area of rocky shores or salt marshes.

Very useful work is in progress by the Oil Pollution Research Unit based at the Orielton Field Studies Center on Milford Haven. Long-term effects of oil fractions and of oil spill removers are being investigated. Experiments simulate field conditons by using short sharp sublethal doses of toxic detergents followed by recovery tests. There are oil-polluted experimental plots on the shore and marsh to provide controlled experiments and to follow up the effects of accidental spills. Accounts are available in the first annual report of the Field Studies Centre (Warden - E. B. Cowell)[8] and by A. Nelson Smith.[9]

On salt marshes, the once-only spill can have nasty effects but the seriousness to vegetation will depend on the time of year. Chronic pollution of marshes can certainly cause serious damage. When the grasses are destroyed, the habitat itself begins to erode away. Lesser damage may interfere with the area as a bird feeding-ground.

At present, dispersant application is strongly contra-indicated in estuaries or enclosed waters where there are shellfish of economic importance because of possible direct toxic effects and because of the increased risk of tainting from more widely-dispersed oil. Mussels can, however, readily pick up oil even without artificial dispersal. Much of it passed through the gut without harming them, but some may be left as a taint. Man detects very low quantities of oil-tainted flavor in fish or shell fish and once a source of food has become suspect, the market is spoiled for a long time even though the damage may not be serious.

In The Sublittoral Zone

After the *Torrey Canyon* incident, we certainly did have local damage in the sublittoral zone, due to detergents running to waste, partly through lack of experienced operators. The effects on economic species, chiefly crabs and lobsters, were slight and temporary. The oil fortunately did not reach any of our oyster beds and even in Brittany by hard work and good fortune, the trouble was not as bad as expected. The incident has served as a very useful warning, alerting world attention to marine pollution problems as a whole.

Since food supplies from the sea will be in ever increasing demand, we must do all we can to minimize the damage from accidental or chronic oil pollution. This is an ecological effect of oil in a much wider sense.

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Microbial Modification Of Crude Oil In The Sea

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Abstract

Virtually all kinds of hydrocarbons and crude oils from many fields are susceptible to microbial oxidation. More than a hundred species of bacteria, yeasts, and fungi are able to oxidize hydrocarbons. Each species is limited in the kinds of hydrocarbons it can attack. Each species is also limited by the temperature, salinity, surface tension, pH, oxygen tension, and other environmental conditions at which it is biochemically active. Environmental conditions also affect the rate of microbial reporduction and oil oxidation. Enrichment cultures, consisting of several different species growing under optimal conditions, tend to convert crude oils and refinery products mainly to carbon dioxide and microbial biomass. From 10 to 90 per cent of the carbon may be converted into microbial biomass.

Oil-oxidizing bacteria are most abundant in coastal waters and mud where oil pollution is chronic. Such bacteria are extremely scarce in the open sea. In unpolluted waters the ratio of oil oxidizers to the total bacterial population in marine environments ranges from 1:100 to 1:10,000. In chronically oil-polluted coastal areas from 5 to 50 per cent of the bacteria may be able to oxidize one or more kinds of hydrocarbons. In such areas, bacteria in well-oxygenated waters might oxidize oil at rates ranging from 0.02 to 2 grams per square meter per day at 20° to 30°C.

Nearly all kinds of gaseous, liquid, and solid hydrocarbons in the paraffinic, oleofinic, and naphthenic series are susceptible to microbial oxidation. The microbial oxidation of hydrocarbons nearly always results in the formation of water, carbon dioxide, microbial cell substance or biomass, and a great variety of other end products, many of which have not been identified. More than a hundred species of bacteria, yeasts, and fungi have been found to oxidize one or more kinds of hydrocarbons. Such hydrocarbon oxidizers are widely distributed in oil-field soil, sump waters, and coastal areas, particularly in places subjected to frequent pollution by petroleum or refinery products. There are several reviews of the extensive literature on various aspects of the subject.[3, 7, 15, 22, 23, 48, 52, 71, 77, 78, 79]

Whether a given crude oil or product refined therefrom is attacked in marine environments depends upon several interrelated factors. Microorganisms capable of oxidizing hydrocarbons must be present and able to grow in the environment. Temperature, salinity, concentration of microbial nutrients, available oxygen, and the dispersion of oil in water are environmental conditions which govern the growth and physiological activities of microorganisms. Toxic pollutants such as hydrogen sulfide, cyanides from industrial wastes, certain heavy metals, free chlorine as in heavily chlorinated sewage, and phenols or cresols are examples of substances which may inhibit the growth of hydrocarbon oxidizers.

Occurrence of Oil Oxidizers in the Sea

Except in the immediate vicinity of land, neither oil-oxidizing yeasts nor mold fungi have been found in the sea. In order to place this generalization in proper perspective, though, it should be pointed out that relatively little effort has been devoted to looking for such microorganisms in the sea. Fewer than 5000 samples from the sea, which covers nearly 70 per cent of the earth's surface, is an average of only one sample per 28,000 square miles!

Oil-oxidizing bacteria appear to have a somewhat wider distribution in marine environments than yeasts or fungi, but such bacteria are only rarely found in the open ocean. Out of several hundred 10- to 50-ml samples of

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[3] Superior numbers refer to literature references at conclusion of text.

seawater collected beyond the continental shelf, fewer than 5 per cent have contained bacteria which could oxidize liquid hydrocarbons.

Tests for such bacteria consisted of treating 10- to 50-ml samples of recently collected seawater with medium- or light-weight paraffin oil along with enough ammonium nitrate and potassium phosphate to satisfy the nitrogen and phosphorus requirements of microorganisms. Either a millionfold or more increase in the microbial population or the modification of the mineral oil was accepted as evidence for the presence and activity of oil-oxidizing microorganisms. Microscopic observations were generally required to ascertain whether the microorganisms were bacteria, yeasts, or fungi. The minimum dilution or multiple tube technique,[2] with oil-enriched media, is commonly used to determine the most probable number (MPN) of oil-oxidizing bacteria in samples of soil, sediment, or water. For further details concerning analytical procedures, consult the literature.[29, 82]

Oil Oxidizers in Intertidal Areas. Wherever surveys have been conducted along the coast, oil-oxidizing microorganisms have been found in at least some of the 10- to 50-ml samples of seawater or bottom sediments collected between 40° S. Lat. and 60° N. Lat. I am aware of no surveys at higher latitudes. Most of the surveys have been made in the vicinity of coastal settlements or oil fields by people concerned with oil pollution or the microbial oxidation of oil. MPN values have been shown to range from < 0.1 to $> 10^8$ oil-oxidizing organisms per ml of marine mud or seawater.

One of the most extensive surveys was made along the coast of Louisiana by ZoBell and Prokop.[82] During a 3-year period they examined mud and water samples from more than 200 stations in the Barataria Bay region. Tests were positive in all 10-ml samples. In one series of 84 mud samples diluted to 10^{-6}, the MPN was $> 10^6$ in 8, $> 10^5$ in 11, $>10^4$ in 25, and $> 10^3$ in 31 samples. In only 2 of the 84 samples were there fewer than 100 oil oxidizers per ml of mud. In another series of mud samples diluted to 10^{-9}, the MPN was between 10^8 and 10^9 per ml in several. The media were enriched with light-weight paraffin oil.

Employing identical methods, samples were assayed from 24 stations along the coast of Texas between Brownsville and Matagorda Bay. At 7 of these stations, negative results were obtained with 10-ml samples, meaning an MPN of < 0.1 per ml. At only 11 of the 24 stations was the MPN $> 10^4$ per ml.

Along the coast of southern California, the population of oil-oxidizing bacteria was found to range from nil in some 10-ml samples to $> 10^8$ per ml of mud. The largest populations occurred in San Pedro and Long Beach Harbors. Samples of beach sands and coastal seawater only rarely contained more than 10^4 oil-oxidizing organisms per ml, and often none could be demonstrated in 10-ml samples. From month to month at the same station, the population of oil oxidizers often changed by 4 or 5 orders of magnitude.

Oil-oxidizing bacteria, yeasts, and molds have been demonstrated in water and mud samples collected in harbors, bays, and estuaries in many parts of the world.

Biodegradability of Crude Oills

Crude oils from different fields and from different strata in the same field differ greatly in physical properties and chemical composition.[27] Along with hundreds of different kinds of hydrocarbons differing in their biodegradability and toxicity, most crude oils also contain small quantities of nitrogenous, oxygenated, and/or organic sulfur compounds. Such differences in composition help to account for the great differences observed in the vulnerability of various crude oils to microbial degradation. Observed differences in biodegradability are often also attributable to experimental or environmental conditions, especially the kinds of microorganisms which are involved.

I have never found a single microbial species which could noticeably degrade any crude oil, but most crude oils examined have been slowly degraded, oftentimes almost completely to carbon dioxide and microbial biomass, by *mixed cultures* consisting of numerous species. Most microbial species are highly selective in their ability to attack various constituents of petroleum and products formed therefrom.

In bringing about the complete degradation of crude oil, organisms which attack various hydrocarbon decomposition products, including complex organic acids, alcohols, ketones, etc., are as important as the organisms which breach hydrocarbons. In enrichment cultures, bacteria which utilize oil-oxidation products are generally more abundant than those which attack pure hydrocarbons. Attempts have not been made to identify all the microbial species involved in the degradation of crude oil by mixed cultures in seawater media, but from 20 to 30 different morphological and colonial types can usually be detected in most experiments.

Observations on Crude Oil. Circumstances attending the disappearance of crude oil spilled in soil, enclosed ponds, and other localized areas point to the involvement of oil-oxidizing bacteria. The gradual modification and disappearance of oils added to marine mud, pond waters, or moist soil, while oil persisted in similar sterilized mixtures, have demonstrated microbial degradation of oils from many fields.

More than 50 years ago, Sohngen[59] reported the oxidation of Russian and American crude oils by soil bacteria. As much as 750 mg of certain oils was oxidized per square meter per day at 28°C. During the last 50 years there have been numerous reports on the microbial degradation of various crude oils under both field and laboratory conditions.[15, 77, 82]

ZoBell and Prokop [82] examined crude oils from 58 oil fields in California, Louisiana, Oklahoma, Pennsylvania, and Texas for susceptibility to microbial degradation. Within 12 weeks at room temperature (21° to 28°C) every one of these crude oils (stripped of volatiles) was attacked by mixed enrichment cultures. This was indicated by either a. changes in the physical appearance of the oil, b. disappearance of the oil, c. weight loss of oil as compared with sterile controls, or d. oxygen uptake (BOD). When approximately 1 gram of volatile-free crude oil was added to 100 ml of aerated seawater enriched with potassium phosphate and ammonium nitrate, between 26 and 98 per cent of the oil was degraded by mixed cultures within 30 days at 25°C. Under similar conditions in sterile controls, there were from 0.3 to 6.7 per cent decreases in oil, attributable to autoxidation. Various fractions of certain crude oils resist bacterial degradation.[28]

After 9 weeks, 100-ml samples of most crude oils overlayering seawater in cylinders disappeared from sight, whereas most of the oil persisted in controls preserved with 0.6 per cent tricresol.[82] A little ether-soluble unsaponifiable residue was recovered from the bottom of cylinders in which the crude oil disappeared. It was not determined what percentage of the oily residue was extracted from oil-oxidizing bacteria which increased many millionfold in abundance during the course of the experiments. Certain bacteria, like many other kinds of living cells, contain from 0.1 to 2 per cent or more liquid and/or solid hydrocarbons, prominently normal paraffins.[7, 12, 15, 18, 24]

Toxic Substances in Crude Oils. High concentrations of a good many hydrocarbons and other components of petroleum may be bacteriostatic or bactericidal. Under ordinary environmental conditions, though, only a relatively few components of petroleum occur in sufficiently high concentrations to be injurious to microorganisms. Certain microorganisms may survive for weeks or months in crude oil or in reservoir fluids consisting of various proportions of oil and water.

In aqueous media as little as 0.01 per cent of such toxic substances as toluene, xylene, mesitylene, phenol, and cresol may inhibit the growth of certain sensitive microorganisms. On the other hand, other microorganisms may tolerate more than 0.5 per cent of these toxic substances. Bartels [5] described nine species of soil bacteria which could survive or grow in the presence of 0.38 per cent phenol. Among 96 other species of soil bacteria examined by Bartels, 46 could grow in the presence of 0.1 per cent phenol. Many microbial species have been examined which grew in the presence of 0.1 per cent of either phenol, cresol, toluene, naphthalene, paradichlorobenzene, or naphthol and used these compounds as the sole source of energy.[21]

Claus and Walker[13] investigated several strains of *Achromobacter* and *Pseudomonas* which grew with toluene, benzene, catechol, benzyl alcohol, or cresol as the sole source of carbon and energy. The oxidation products included acetic acid and pyruvic acid.

In most cases, when crude oils are mixed with seawater in proportions of one to fifty or more, not enough toxic components are dissolved in the aqueous phase to prevent microbial growth, although certain species may not grow or survive. Various microbial species differ greatly in their tolerance for toxic components in petroleum, and various crude oils differ greatly in their content of toxic substances.[28]

In assessing the ecological effects of oil in marine environments, much more information is needed on the toxicity of various petroleum components as well as the toxicity of oil-oxidation products for marine organisms, particularly the effects of such components or products on plant and animal life.

Biodegradability of Various Kinds of Hydrocarbons. Among the many factors which influence the biodegradability of hydrocarbons, molecular configuration seems to be the most important. In general, alkanes are attacked by more microbial species, more rapidly, and support more growth than either aromatic or naphthenic compounds. Within the alkane series, normal compounds are more susceptible to microbial oxidation than branched chain compounds. Biodegradability decreases as the number of branches increases and increases with the chain length of the branches.

Relatively few species oxidize methane, ethane, or propane, but some of those that do, do so quite rapidly under favorable conditions. Many more species have the ability to oxidize normal alkanes containing 10 to 18 carbon atoms than any other kind of hydrocarbons. With increasing chain length, alkanes seem to be increasingly more refractory to microbial oxidation, which may be attributable more to lower solubility in water than to lack of vulnerability to enzyme action. Waxes containing more than 30 carbons are quite rapidly oxidized by certain microorganisms when properly dispersed in aqueous media.

Certain microorganisms selectively attack unsaturated hydrocarbons, although many more species exhibit a preference for saturated compounds. The microbial oxidation of many different kinds of aromatic compounds has been investigated.[25, 26, 40, 52, 62, 66]

Introducing alkyl groups into the benzene ring tends to render the resulting compound more susceptible to microbial oxidation.[40] Toluene, $C_6H_5CH_3$, is generally more susceptible to bacterial oxidation than benzene, C_6H_6, xylene, $C_6H_4(CH_3)_2$, more than toluene, and mesitylene, $C_6H_3(CH_3)_3$, more than xylene. Soil bacteria which grew fairly well on butylbenzene, $C_6H_5C_4H_9$, failed to utilize either benzene or toluene.[25]

Although many exceptions have been noted, as a general rule, bacteria oxidize polycyclic hydrocarbons more readily than benzene.[78] Naphthalene generally promotes the growth of soil bacteria much more than benzene.[25, 26, 40, 63] Strawinski and Stone[62] found no bacteria in soil enrichment cultures which grew on benzene, but both biphenyl and naphthalene supported large bacterial populations. Tauson [65, 66] also found many soil bacteria which readily utilized biphenyl, naphthalene, anthracene, and phenanthrene. Such bacteria have also been found in the sea.[57] Gibson[25] has reviewed recent advances in the microbial degradation of benzene, anthracene, naphthalene, phenols, and other aromatic compounds.

A series of cycloparaffins from C_3- to C_8-membered rings were shown by Ooyama and Foster [47] to be oxidized by soil bacteria. The cycloparaffins were oxidized in part to the corresponding cyclomonoketones.

Non-Growth Hydrocarbons. The inability of a given microbial species to subsist on hydrocarbons is not proof of its inability to oxidize the hydrocarbons.[22] Probably widespread in nature are organisms which can oxidize certain hydrocarbons but cannot assimilate the primary oxidation products for either energy or cell building material. Enriching the hydrocarbon medium with minute amounts of certain sugars, simple organic acids, or peptones often enables bacteria to grow and to continue to oxidize non-growth hydrocarbons. Likewise, inoculating the hydrocarbon medium with other kinds of microorganisms which can assimilate the primary oxidation products often enables the first species to grow, perhaps at the expense of intermediate products of metabolism of the mixed microflora.

In many cases, mixed cultures have reproduced rapidly and degraded certain hydrocarbons almost quantitatively to carbon dioxide and microbial biomass, although single species isolated from the mixed cultures were unable to grow in mineral media containing only the hydrocarbons as a source of carbon and energy. Such circumstances serve to stress the ecological importance of studying the cumulative effects of mixed cultures on the degradation of crude oils under natural conditions of pollution. However, observations on pure cultures, cells harvested therefrom, or their enzymes acting on pure hydrocarbons are essential for an understanding of microbial metabolic pathways.

Oxygen Requirements for Oil Oxidation

The complete oxidation of 1 mg of hydrocarbon to CO_2 and H_2O requires between 3 and 4 mg oxygen, i.e., the BOD is 3 to 4. The theoretical BOD values for some representative hydrocarbons have been reported by ZoBell and Prokop,[82] who determined the actual BOD values for several crude oils and pure hydrocarbons.

At 20°C the 5-day BOD of 10 ml of various crude oil fractions per liter of seawater was found by Alyakrinskaya [1] to range from 2.46 to 5.40. With higher concentrations of crude oil, dissolved oxygen was depleted. With low concentrations of crude oil, the 5-day BOD at 20°C was between 42 and 64 per cent of the 20-day BOD.

Most hydrocarbon-oxidizing microorganisms require free or dissolved oxygen. When oil oxidizers are in contact with the normal atmosphere, as at the air-water interface, the supply of oxygen is usually adequate. In areas of intense microbial activity below the water surface, particularly in bottom sediments, oxygen may be a limiting factor. This depends upon how rapidly oxygen is consumed and how rapidly it is replenished. Replenishment may be by oxygen diffusion, water turbulence, or photosynthetic activity in shallow water.

Depending largely upon temperature and salinity, the dissolved oxygen content of seawater in equilibrium with the normal atmosphere is between 6 and 11 mg per liter. This much oxygen is required for the complete degradation of from 2 to 4 mg of crude oil. Taking 3 as its mean BOD value, it would require all of the dissolved oxygen in about 320,000 gallons of seawater for the complete oxidation of 1 gallon of crude oil. The complete oxidation of one barrel of such crude oil would require all of the dissolved oxygen in about 40 acre-feet of seawater, assuming no replenishment from the atmosphere or photosynthetic activity.

Provided some free oxygen is available, the oxygen tension does not seem to be a limiting factor until the partial pressure of oxygen becomes so low that oxygen is consumed more rapidly than it can be replenished by diffusion or otherwise.

Other Hydrogen Acceptors. Under certain conditions, a few microbial species are able to attack hydrocarbons in the absence of free oxygen. In laboratory experiments, nitrate has been shown to serve as a hydrogen acceptor for certain hydrocarbon-oxidizing bacteria.[10, 64, 81] A strain of *Pseudomonas aeruginosa* utilized *n*-octane and *n*-hexadecane anaerobically while reducing nitrate to nitrite.[69] Theoretically around 4 mg of nitrate is required for the complete oxidation of 1 mg of mineral oil.

Based on observations with washed cells of *Pseudomonas stutzeri* in manometric apparatus, Hansen and Kallio [30] concluded that pure cultures cannot utilize nitrate as the terminal oxidant for hydrocarbons. They pointed out, though, that "once the hydrocarbon structure has been breached by the introduction of oxygen, by means of peroxidation or oxygenase action, oxidation at the expense of nitrate reduction and, presumably, sulfate reduction occurs readily."

Under natural conditions, it may matter little whether nitrate can provide oxygen for the microbial oxidation of oil in anaerobic environments, because nitrate is generally absent. However, from an ecological, industrial, or engineering point of view, it may be of importance to know whether treating oil-polluted waters or oil-fermentation tanks with nitrate promotes the oxidation of oil.

The utilization of hydrocarbons by strictly anaerobic sulfate-reducing bacteria has been reported by several investigators.[16, 17, 19, 31, 38, 46, 54, 68, 69, 82] In 78 out of 100 mud samples from Barataria Bay, 1-gram inocula were found by ZoBell and Prokop [82] to decompose mineral oil under strictly anaerobic conditions and to reduce sulfate. Similar observations were made by Ivanov,[31] who demonstrated that mixed cultures from various sources reduced sulfate in mineral media with crude oil as the only source of organic matter. His observations, however, failed to prove whether pure cultures of sulfate-reducing bacteria can oxidize petroleum hydrocarbons.

The majority of 38 cultures of sulfate-reducing bacteria isolated from oil fields were found by Dostalek *et al.* [16] to assimilate paraffinic hydrocarbons. Some of these cultures (probably mixed) reduced the relative viscosity of certain mineral oils from 115.3 to 112. About half of the 47 cultures of sulfate-reducing bacteria examined by Updegraff and Wren [74] reduced sulfate in mineral media enriched with a mixture of hexadecane and crude oil.

It seems doubtful whether pure cultures of sulfate-reducing bacteria assimilate highly purified hydrocarbons in mineral media containing no other source or organic carbon. There is overwhelming evidence, though, that certain mixed cultures slowly oxidize hydrocarbons while reducing sulfate. The reaction is accelerated by traces of organic nutrients in concentrations much too low to account for the quantities of sulfate reduced.

Dispersion of Oil in Water

Under otherwise comparable and optimal cultural conditions, the rate at which most liquid and solid hydrocarbons are oxidized is limited by their solubility or dispersion in aqueous media. The concentration of gaseous hydrocarbons in aqueous media is largely a function of the partial pressure of each. Owing to the low partial pressure in open systems, rarely is as much as 10 ppm of any gaseous hydrocarbon found in the sea. The solubility of only a few liquid hydrocarbons is more than 10 ppm in water at temperatures extant in the sea (mostly -2° to 30°C). The vast majority of liquid and solid hydrocarbons are less soluble than 1 ppm.

Aqueous emulsions, dispersing agents, and adsorption of hydrocarbons on solid surfaces help to render them susceptible to the action of enzymes. Prerequisite to microbial oxidation, properly oriented molecules must come into contact with specific catalyzing enzymes and active oxygen. There are many ways in which natural and/or experimental conditions help to satisfy this prerequisite.

Ways in Which Oil May Be Dispersed. Providing relatively large air-surface areas helps to place more oil in contact with aqueous media and with atmospheric oxygen. In nature, the sea provides the largest surface area over which certain oils may spread to almost monomolecular thinness. A gallon of spreading oil could cover many acres.

Sharp shaking or sparging oil and water mixtures with air tends to disperse both oil and oxygen throughout the medium.

Certain chemical emulsifying or oil-dispersing agents often help to make oil more available to microorganisms by increasing the contact of hydrocarbon molecules with microbial enzymes and oxygen. But, in experimental work in the laboratory as well as in field applications, all due precautions must be taken to avoid adding such chemical agents in deleterious concentrations, because: (a) Many detergents and emulsifying agents are bacteriostatic in concentrations no higher than a few parts per million, (b) Certain oil-dispersing agents may provide preferred sources of carbon for bacteria, thereby diminishing the oxidation of hydrocarbons or making it difficult in laboratory experiments to tell whether bacterial growth or oxygen uptake is attributable to hydrocarbon or additive oxidation, (c) High concentrations of detergents or other oil-dispersing agents may be injurious to plant and animal life in the sea. The excessive use of detergents off the coast of West Cornwall, following the wreck of the tanker *Torrey Canyon* in 1967 when about 120,000 tons of Kuwait crude oil was spilled in the sea, probably damaged marine life much more than the oil.[8, 14, 34, 45, 58, 76]

Absorbing oil on solids such as sand grains, ground glass, glass wool, asbestos fibers, chalk, gypsum, and other chemically inert particles often promotes the oxidation of oil by virtue of the increased surface exposed to microbial enzymes. Probably such adsorption of oil on particles also results in more favorable orientation of hydrocarbon molecules.[77, 80] Dispersing oil in solidified mixtures of calcium carbonate and calcium sulfate (Plaster of Paris) renders it much more susceptible to microbial oxidation.[67, 77] In order to help counteract the adverse effects of oil from the *Torrey Canyon* along the North Brittany coast, the French used about 3000 tons of chalk (largely calcium carbonate) treated with sodium stearate. The latter is an effective emulsifying agent. The mixture of chalk and sodium stearate, called "craie de Champagne," is believed to have made the oil more available to microorganisms.

The French workers believed, but failed to prove, that the phagotrophic flagellate, *Noctiluca miliaris*, ingested the oil-soaked "craie de Champagne" along with large numbers of attached bacteria. Such particles are known to be ingested by numerous species of protozoans and by myriads of other socalled mud-eaters or filter-feeders which are generally abundant in coastal waters and on the sea floor. Except under the most extreme conditions, there is no evidence that such animals are injured by oil pollution. Certain animals digest oil, although it has yet to be determined the extent to which intestinal bacteria contribute to the oxidation of ingested hydrocarbons. Unquestionably, the bacteria which animals ingest contribute substantially to the nutrition of many species.

Heating aqueous mixtures of oil generally increases the dispersion of liquid and solid hydrocarbons. Such dispersion, however, may be reversible and, moreover, there are practical limits in the laboratory as well as in the sea to which aqueous mixtures of oil can be heated.

Effect of Temperature

More important than its effect on the solubility or dispersion of oil in water is the effect of temperature on the rate of microbial growth and activity. To set the stage for this discussion, it should be pointed out that the temperature range of more than 99 per cent of the marine environment by volume or area is -2° to 30°C. This is the range within which most species of marine microorganisms grow best, although microbial growth has been observed in the laboratory at temperatures as low as -7.5°C and as high as 95°C at normal pressures.

The microbial decomposition of hydrocarbons has been demonstrated at temperatures as low as 5°C and as high as 70°C. Klug and Markovetz [33] observed the growth of bacteria on *n*-tetradecane at 45° to 70°C. Enrichment cultures of a thermophilic *Bacillus* utilized normal C_{12}-C_{20} alkanes at temperatures ranging from 37° to 70°C.[39] Most observations have been made at temperatures between 20° and 37°C. Studies on microbial dissimilation of other carbon compounds at low temperatures suggest that certain species may be able to oxidize hydrocarbons at temperatures at least as low as -2°C, the freezing point of high salinity seawater.

Species, salinity, pH, nutrients, and pressure are some of the factors which influence microbial reproduction rates at different temperatures. Under non-stress conditions at temperatures below their optima, the generation time of most bacteria increases from two- to threefold for each 10°C decrease in temperature. Thus a given species, which reproduces most rapidly at 25°C, may reproduce only one-half to one-third as rapidly at 15°C, and only one-half to one-third as rapidly at 5° as at 15°C. This means that, when growth is at the expense of oil, theoretically this species could be expected to oxidize the oil only 1/9 to 1/4 as rapidly at 5° as at 25°C. The few species which have been tested oxidized hydrocarbons from 10 to 20 times more rapidly at 25° than at 5°C. A culture studied by Sohngen [59] was found to oxidize as much paraffin wax in two days at 28°C as in a week at 20°C. Similarly, Stone *et al.* [61] found hydrocarbon oxidizers to be much more active at 30° than at 20°C.

Microbial Activity at Low Temperatures. It is not known whether psychrophilic oil oxidizers exist or whether such microorganisms could be "trained" to oxidize oil rapidly at refrigeration temperatures, say -2° to 5°C. Other kinds of cold-loving bacteria which grow best in cool ($<$ 15° to 20°C) media or environments, abound in certain refrigerated foods,[20] in Antarctic waters,[49] and in the deep sea where the temperature is nearly always lower than 5°C.[83, 84] The basic nature of marine psychrophilic bacteria has been reviewed by Morita.[43]

The obligate marine psychrophile, *Vibrio marinus,* reproduces rapidly and oxidized glucose at 4°C and also at 15°C.[43] Its maximum temperature is around 20°C. Its generation time was 80 minutes at 15°C and 226 minutes at 3°C.[44]

The generation time of microorganisms at various temperatures is influenced by other environmental conditions and especially by the nutrient composition of the medium.

Nitrogen and Phosphorus as Nutrients

Besides energy sources, oil oxidizers, like all other kinds of microorganisms, require utilizable sources of C, Ca, Mg, K, S, Fe, N, and P, plus various trace elements. With the exception of utilizable organic carbon, nitrogen, and phosphorus, all of the elements in utilizable forms are usually in adequate supply in soil and seawater. A lack of utilizable compounds of nitrogen and sometimes phosphorus may limit the growth of oil-oxidizing microorganisms in seawater.[32, 35]

In laboratory experiments, it is nearly always necessary to enrich seawater with compounds of nitrogen and phosphorus to provide for the maximum growth of oil oxidizers. The nitrogen and phosphorus requirements of most oil oxidizers are satisfied by the addition of several parts per million of ammonium phosphate. Equivalent quantities of other salts such as ammonium sulfate, ammonium chloride, ammonium nitrate, potassium phosphate, sodium phosphate, or calcium phosphate, for example, serve just as well and may have certain biological or economic advantages.

Laboratory experiments suggest that a lack of available nitrogen and possibly phosphate might be a limiting factor for the growth and activity of oil-oxidizing microorganisms in certain marine environments. For optimal operation of biofilters designed to free waste waters of hydrocarbons, it is sometimes necessary to enrich the waste waters with appropriate sources of nitrogen and phosphorus. A good many other compounds besides ammonium salts may satisfy the nitrogen requirements of certain microorganisms. Nitrates may be assimilated by some oil oxidizers. The rapid disappearance of oil from coastal areas occurred when appropriate sources of nitrogen and phosphorus were provided.[35]

Products of Oxidation

An expansive array of organic acids, lipids, esters, complex alcohols, ketones, aldehydes, polysaccharides, microbial proteins, and other substances have been shown to result from the microbial oxidation of petroleum hydrocarbons.[6, 7, 15, 23, 36, 41, 51, 53, 60, 71, 72] Figuratively, however, the surface has barely been scratched in determining what products might result from the oxidation of the thousands of different kinds of hydrocarbons by the dozens of microbial species under various experimental, industrial, or natural environmental conditions.

An important and almost totally unexplored facet of the oil pollution problem is the effects of oil-oxidation products on marine plants and animals. Microbial proteins and other cell substances synthesized by oil-oxidizing microorganisms are probably beneficial to phagotrophic animals.

Microbial Biomass. Meriting special mention is the microbial biomass resulting from the growth of oil-oxidizing microorganisms. From about 10 to more than 90 per cent of the carbon content of hydrocarbons undergoing microbial oxidation may be converted into microbial cell substance or biomass consisting mainly of proteins, nucleic acids, lipids, and polysaccharides. In marine environments such microbial biomass may contribute substantially to the nutrition of marine animals. The microbial conversion of hydrocarbons into proteins has become an industrially interesting reaction.[11, 15, 55]

A species of yeast belonging to the genus *Candida* was found to convert up to 82 per cent of *n*-octadecane into yeast biomass.[50] Soil *Candida* species studied by Miller and Johnson [42] converted from 71 to 94 per cent of normal C_{12}-C_{18} paraffinic hydrocarbons into yeast biomass, about half of which was protein. These are exceptionally high yields. Yields from mixed cultures after prolonged incubation are often less than 10 per cent. The average yield for numerous pure and mixed cultures of bacteria, yeasts, and molds under various conditions of cultivation fall between 30 and 40 per cent, about half of which is protein.

Oil Oxidation Rates

The rate at which oil undergoes microbial oxidation is influenced by the abundance and kinds of microorganisms, the dispersion of hydrocarbons in the medium, oxygen supply, temperature, the chemical composition of the oil, and several other factors. Above the level of its solubility in water, the amount of oil added to seawater may be detrimental.

Excessive quantities of crude oil or tarry substances may retard microbial oxidation rates for various reasons: (a) Thick layers of oil on the surface of water may diminish the uptake of oxygen from the atmosphere or diminish the penetration of sunlight essential for the photosynthetic liberation of oxygen, (b) Hydrocarbons within multimolecular layers of oil, greases, or tars may be almost completely out of contact with microbial enzymes, water, or free oxygen, and (c) The concentration of water-soluble toxic substances can be expected to increase as the quantity of oil increases in a given area.

Within the range of 0.5 to 50 ml of crude oil per liter of seawater, the 5-day BOD at 20°C was found [1] to increase only 2 to 4 times when the amount of oil was increased 40 to 100 times. Above 50 ml per liter, adding more oil had little effect on its rate of oxidation. In these BOD experiments, various crude oils were oxidized at rates ranging from 0.2 to 2 mg per liter per day at 20°C.

When dispersed on glass wool, paraffin wax was oxidized by marine bacteria in BOD bottles at rates ranging from 0.4 to 1.4 mg per liter per day at 20° C.[77] Believing that contact of oil with culture medium was rate limiting, Tauson and Shapiro [68] expressed the rate of oil oxidation in terms of surface area of water overlayered with oil. Crude oils were oxidized at rates ranging from 0.5 to 1.3 grams per square meter per day at 25°C. There are numerous reports on the microbial oxidation of crude oils, lubricating oils, cutting oils, and oily wastes at rates ranging from 0.02 to 2 grams per square meter per day at 24° to 30°C.[3, 4, 9, 15, 32, 37, 56, 75, 82]

Almost completely lacking are meaningful data on the rate of oil oxidation at temperatures in the psychrophilic range, say -2° to 14°C.

Summary and Conclusions

Under favorable environmental conditions, most kinds of petroleum hydrocarbons and associated products appear to be susceptible to oxidation by various kinds of bacteria, yeasts, and fungi. Such oil-oxidizing microorganisms are often abundant in soil, marine sediment, and seawater in coastal areas where natural or man-induced oil pollution is chronic. Such microorganisms are extremely sparse or absent in the open ocean. Nothing is known about the occurrence or activity of oil-oxidizing microbes in marine environments north of the Arctic Circle or in Antarctic areas.

Mixed enrichment cultures generally degrade crude oils more rapidly and more completely than pure cultures of microorganisms. Degradation products include a great diversity or organic acids, complex alcohols, aldehydes, ketones, microbial proteins, and other substances. It has yet to be determined whether any of the degradation products are produced in sufficient concentrations in marine environments to be injurious to plant or animal life. Depending upon (a) the microbial species present, (b) the composition of the oil, and (c) environmental conditions, from 10 to 90 percent (mean value around 35 per cent) of the carbon content may be converted into protein-rich microbial biomass. Such biomass may provide nutriment for protozoans and other phagotrophic animals.

Microbial degradation seems to be Nature's way of cleaning up chronic oil pollution of surface soil, beaches, and coastal waters. Microbial degradation is most efficient in removing relatively low concentrations of oil. Thin films of oil on the surface of water or on solid surfaces are most vulnerable to microbial attack. Though not effective for the rapid removal of massive volumes, microbial degradation is probably very important in ameliorating and curtailing damage from oil spills. It might be possible to accelerate the microbial process and to increase its effectiveness by treating oil polluted areas with enrichment cultures which have been "trained" to attack the various kinds of hydrocarbons most likely to be present in the area. Seeding oil-polluted areas with enrichment cultures offers promise.

Post-Conference Summary

Most of the generalizations summarized in this paper are based on observations made under carefully controlled experimental conditions designed to simulate the marine environment. All possible precautions should be exercised in extrapolating the results of such experimental work to the assessment of what actually happens in oil polluted areas. It may be nonsense to talk about microbial reaction rates and oil-degradation products in oil-polluted areas unless all cogent conditions in the field and laboratory are comparable. Among the most important conditions which influence the microbial degradation of oil in the sea are the following. (a) abundance and kinds of microorganisms present, (b) concentration of microbial nutrients, especially utilizable nitrogen and phosphorus compounds, (c) oxygen supply, (d) chemical composition of the oil, (e) temperature, and (f) dispersion of oil in water.

Although dispersing oil in water generally promotes its degradation by microorganisms, certain chemical dispersants may inhibit microbial activity in various ways. Certain dispersants are toxic because they damage cell-membrane permeability or because they irreversibly denature essential enzymes. Certain dispersants inhibit microbial activity by reducing the surface tension of aqueous media to unfavorable levels. For most bacteria the lethal level is between 25 and 35 dynes/cm. Surface tensions lower than 45 dynes/cm are often inhibitory. Oil-oxidizing microorganisms are generally most active in aqueous media having a surface tension between 45 and 60 dynes/cm. This is considerably less than the surface tension of normal seawater (73 to 74 dynes/cm at 20°C). Thus a little surface-tension depressant may promote the microbial degradation of oil, but too much may have a retarding or lethal effect.

Foremost among the many unsolved problems confronting environmental engineers concerned with oil pollution are the following: (a) the compatibility of various chemical dispersants with microorganisms, (b) the effects of oil-oxidation products on the well-being of plant and animal life, (c) the rate and extent of oil oxidation at temperatures in the range of -2° to 15°C, (d) data on the abundance and kinds or varieties of oil-oxidizing microorganisms in areas subject to oil pollution both before and after the area has become polluted, and (e) observations on the concentration of dissolved oxygen and microbial nutrients in oil-polluted areas to ascertain whether either becomes a limiting factor for oil oxidation.

Owing to the time required for the microbial degradation of oil, the microbial method cannot be recommended as a means for quickly cleaning up massive oil spills. Microbial degradation seems to be most effective for removing films or minute droplets of oil from water, beaches, shellfish beds, and other submerged surfaces.

This seems to be Mother Nature's way of cleaning up oil pollution in soil and sea. Man must cooperate with Nature by not overloading the ecosystem and by not upsetting the biological balance. When oil is spilled, I recommend the quick removal of as much oil as possible after which seeding with appropriate mixed cultures might be indicated depending upon the circumstances. The use of non-toxic dispersants or other emulsifying agents may accelerate the microbial degradation of oil.

During the final discussion period on December 17, there was a question from the floor concerning fungi as oil oxidizers. Numerous kinds of fungi, yeasts, and closely related actinomycetes have been shown to degrade a wide variety of crude oils and derivatives therefrom ranging from kerosene and jet fuel to paraffin wax.[77] Species of *Aspergillus, Botrytis, Candida, Cladosporium, Debaromyces, Endomyces, Fusarium, Hansenula, Monilia, Penicillium, Actinomyces, Micromonospora, Nocardia, Proactinomyces,* and *Streptomyces,* which oxidize a great variety of hydrocarbons are widely distributed in soil, freshwater, and coastal waters. From 178 water samples associated with jet fuels Churchill and Leathen (U.S. Air Force, A.S.D. Tech. Rept., 61-193, pp. 1-66, 1961) isolated 75 fungal types and 104 bacterial types. According to Davis,[15] organic material of "paraffin dirt" is heavily impregnated with fungi, yeasts, actinomycetes, and bacteria.

The question from the floor concerning the biodegradability of carcinogenic hydrocarbons was answered in part by citing a paper by Sisler and ZoBell entitled "Microbial Utilization of Carcinogenic Hydrocarbons" (*Science*, vol. 106, p. 521, 1947). Phenanthrene, 1,2-benzanthracene, 1,2,5,6-dibenzanthracene, and several other polycyclic hydrocarbons were shown to be from 11 to 68 per cent oxidized to carbon dioxide by mixed cultures of bacteria within four days at 32°C. The microbial metabolism of polycyclic hydrocarbons is treated in much greater detail in books by Beerstecher[7] and Davis.[15]

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Microbial Degradation Of Normal Paraffin Hydrocarbons In Crude Oil

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Abstract

Experiments designed to measure the oxidation and degradation of crude oils by naturally occurring marine microorganisms are presently being conducted. Fifty active oil degrading cultures have been isolated in enriched seawater containing crude oil. Oil degradation has been determined with gas chromatography, wet combustion, and by measurement of surface tension. Normal paraffin hydrocarbons through C-26 are degraded by two different groups of microorganisms–those growing in the oil phase only and those growing in the aqueous phase. Emulsification of the crude oil through production of surfactants was observed in many of the enriched cultures. Microbial degradation of 35 to 55 per cent of oxidizable crude oil occurred within 60 hours.

It is generally known, supported by the lack of recent petroleum deposits, that indigenous microbial populations must eventually degrade in our geological time most of the hydrocarbons which are released into the marine environment.[1] Removal of hydrocarbons from the sea surface by microorganisms can be effectively significant through two functional aspects–direct oxidation for carbon and energy to CO_2 or intermediate products,[2,3,4] or by production of surfactants which may emulsify more recent oil materials.[5]

Because of the significance of oil pollution today, it is necessary to understand the above microbial processes with the thought of increasing microbial oil degradation by seeding an area where oil has been introduced. Thus, it may be possible that large quantities of selected microorganisms, offered growth enhancing properties, could hasten degradation and ultimate removal of pollutant hydrocarbons.

We have recently begun a study, sponsored by the FWPCA, to determine the feasibility of such a seeding operation to aid in oil spill cleanup operations in the marine environment.

Methods

Initial experiments, in addition to determining nutrient requirements and isolation procedures, were designed to measure microbial produced changes in oil at water interfaces and in straight chain hydrocarbons in crude oil. For isolation of cultures, soil and water continuously exposed to hydrocarbons for several years were sampled. Oil oxidizing organisms, to be described later, were isolated off the California coast (C-63), from Boston Harbor (BHMO), from a refinery drainage ditch in Pennsylvania (SOCLA), near an oil rig in the Gulf of Mexico (OILRIG), in the ship channel at the Florida State University Marine Laboratory on the Gulf of Mexico (TPLA), and in a thick oil film on the Mississippi River near New Orleans (NOLA). For experimental purposes, a light southwest Louisiana crude and an asphaltic California crude (E-76) have been used as reference hydrocarbons.

Oil active microorganisms were isolated from oil contaminated seawater and sediments by techniques based on work by Bushnell and Haas (1941) and Davis (1967). The following scheme has been followed.

Approximately 1.0 ml liquid or a 0.1 gm soil sample was added to a 50 ml Erlenmeyer flask containing 20 ml enriched seawater of the following composition: 1 PPT $(NH_4)2\ SO_4$, 10 PPM K_2HPO_4, 5 PPM yeast extract, and 10 PPM EDTA, adjusted so the final PH after sterilization was 8.1. The mixture was overlain with 5 drops of 0.45 micron membrane filtered crude oil, vigorously rotated for

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[1] Superior numbers refer to literature references at conclusion of text.

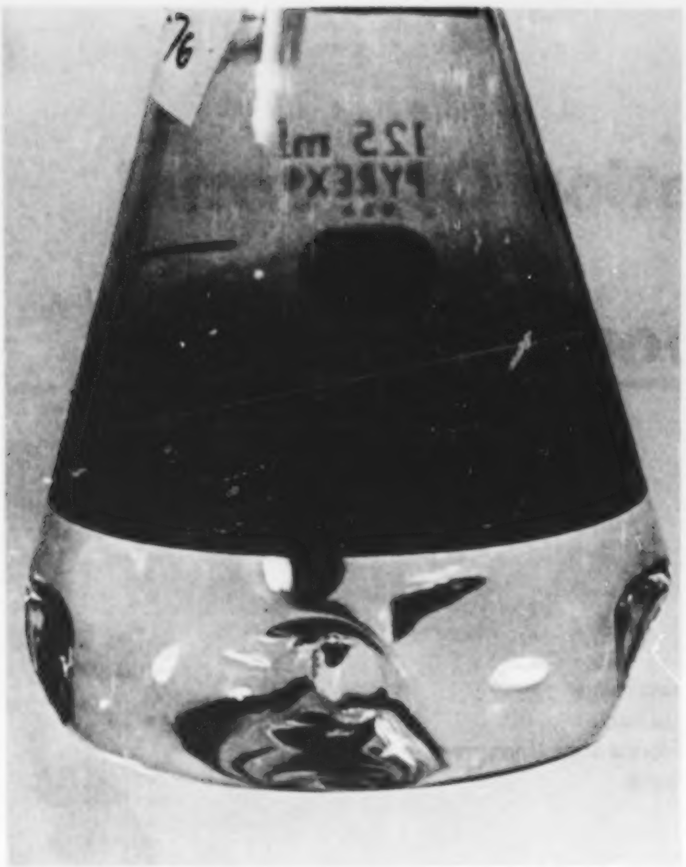

Figure 1. Control sample of a California crude.

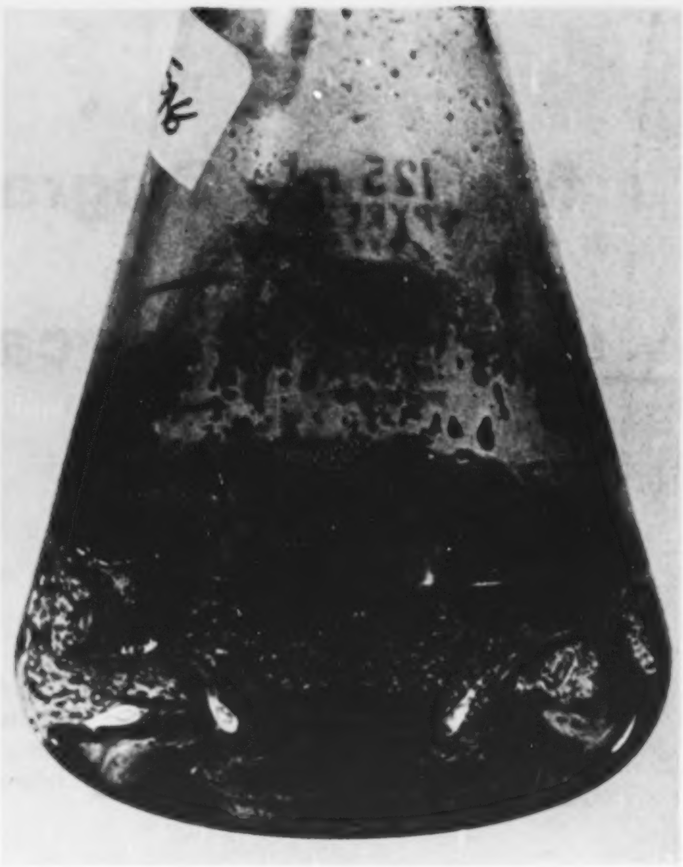

Figure 2. Sample shown in Figure 1 after 72 hours growth of an oil positive culture.

48 hours at 32°C, then scored positive or negative based on cell density and oil emulsifying ability. A loopfull of the most active cultures was then transferred twice on the same medium with 48 hour incubation periods and thereafter maintained on an enriched seawater agar + oil slant.

Experiments were conducted following the classical bacteriological technique of streaking the cultures out on a seawater agar + oil plate, picking colonies, then maintaining and working with pure cultures. However, the various pure cultures, even when recombined, invariably resulted in the loss of hydrocarbon degrading ability as compared to the original mixed culture. Others[4] have also used mixed populations to study microbial degradation of crude oils. Our mixed cultures maintain themselves well on slants, and approximately 50 cultures are presently being examined.

The cultures are designated by origin of sampling and have not yet been characterized for individual strains of microorganisms. Of our fifty cultures in stock, results of crude oil degradation by six of our most active mixed cultures previously referred to by sample location, will be reported here.

Several methods have been devised to quantify rates of oil degradation by microorganisms. B.O.D. has been used to calculate rates of hydrocarbon consumption under ideal conditions,[7] as has weighing the residual crude after extraction.[4] Other methods include combustion and carbon balance.

Each of these techniques has its limitations. For our work we chose the following scheme which we felt would give us the most information to use in selecting appropriate cultures as seed organisms.

1. Growth in enriched seawater
2. Observation of the aqueous and oil phases
3. Surface tension
4. Benzene extraction and Gas Chromatography
5. Wet Combustion

To attain maximal growth one loopfull of a 48 hour liquid culture was inoculated into 50 ml of enriched seawater overlain with 0.1 per cent sterile crude oil. The culture was incubated at 32°C on a rotary shaker. This seawater to oil ratio limits maximal hydrocarbon degradation as cell densities of 10^9 cells/ml and pH changes from 8.1 to 5.6 were produced after 36 hours. Further activity was apparently severely limited under these crowded conditions and pH change. We have since shown that increasing the seawater to oil ratio permits more complete oxidation of the crude oil. A "chemostat" type of apparatus is presently being tested that may alleviate the problems inherent in a closed system.

After a period of growth visual changes in the aqueous phase (such as cell density, color, pH), as well as changes in the oil film (emulsification and inability to coat the container walls) were used to identify microbial activity.

Two distinct types of cultures active on the crude oils have been isolated – microorganisms that grow in the oil phase only (these will be referred to as oil positive), and those that grow in the aqueous phase. Figure 1. shows the control sample of a California crude (E-76). There is a distinct surface film and the oil clings to the side of the

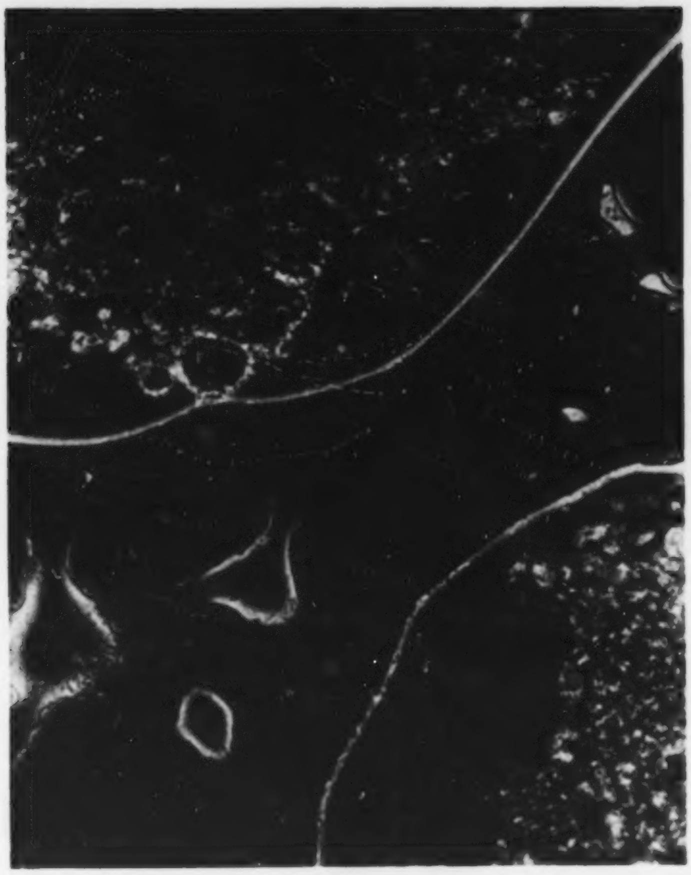

Figure 3. Fluorescent photomicrograph of an oil positive culture.

Figure 4. Emulsification of California crude after 72 hours growth of C-63 culture.

flask. The same California crude after 72 hours growth of an oil positive culture (NOLA) has been degraded to small thin flakes and no longer coats the walls of the container. This is shown in Figure 2.

Another oil positive culture (SOCLA) grows first in the oil phase, leaving a flaky residue, then begins to grow in the water. Figure 3. is a fluorescent photomicrograph of this organism. The bacteria (rods) are in the crude oil residue itself which fluoresces red. Figure 4. shows emulsification of the California crude after 72 hours growth of the C-63 culture. The cells grow in the aqueous phase and emulsify as well as degrade the oil. The production of surfactants is indicated by the inability of the oil to cling to the side of the flask.

Each culture was then allowed to stand undisturbed for two hours at which time the surface tension was determined using a DuNouy tensiometer. For this particular experiment California crude was used, and surface tension was measured after 72 hours growth in enriched seawater containing 0.1 per cent crude oil (Table 1).

These data are difficult to interpret since in some cultures two competing processes are occuring simultaneously–that is, the removal of hydrocarbons by conversion to cell carbon, CO_2, and water soluble intermediate products, decreasing the oil film thickness thus increasing the surface tension, and the production of surfactants which decrease the surface tension.

TPLA, an aqueous phase culture, originally isolated on Louisiana crude did not grow well and had a value only slightly higher than the control. The other three aqueous phase cultures, BHMO, OILRIG, and C-63 had higher values indicating a decrease in surface film thickness (no surface film was visible), but they also produced surfactants as evidenced by the formation of a hydrocarbon-water interface emulsion that was difficult to separate when the cultures were later extracted with benzene.

TABLE 1. SURFACE TENSION

Sample	Dynes CM^{-1}	
Seawater	71.3 ± 0.1	
Control-E-76 crude on seawater	40.4	1.0
TPLA	44.6	1.0
BHMO	48.2	0.6
OIL RIG	48.1	0.5
C-63	48.8	0.6
SOCLA	37.1	0.4
NOLA	34.7	0.5

1. Measured after 72 hours growth of oil oxidizing microorganisms on 0.1% California crude oil (E-76).

The two oil positive organisms, NOLA and SOCLA, had lower surface tension values than the control. When these cultures were extracted with benzene, however, the phases separated easily, indicating a lack of surfactant production. These low values may have been due to the flaky residue coating the tensiometer platinum ring.

The crude oil was then extracted with benzene, the solvent evaporated, and a small portion (usually 1 microliter) of the residual oil analyzed on the gas chromatograph. Adamantane, a microbial resistant, cyclic,

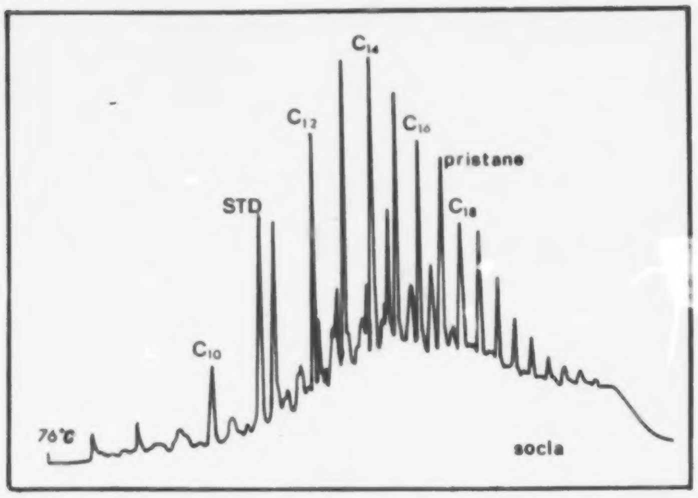

Figure 5. Gas chromatograph trace of undegraded (control) Louisiana crude oil.

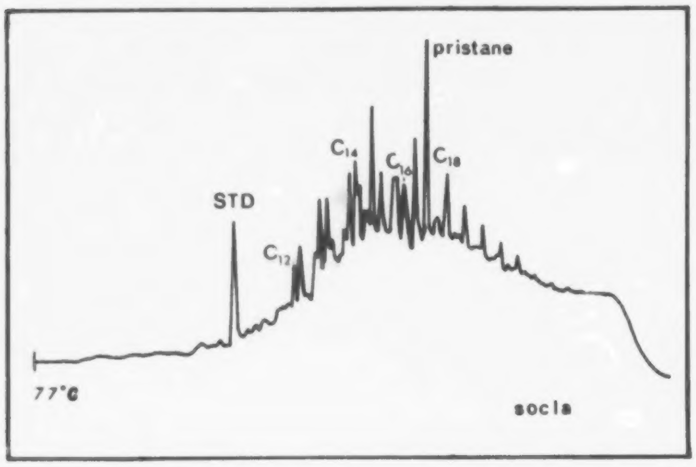

Figure 6. Gas chromatograph trace of Louisiana crude oil (0.1% in 50 ml enriched seawater) after 48 hours degradation by oil-positive microbial culture SOCLA.

highly branched hydrocarbon was added to the original crude oil substrate to serve as an internal standard. However, the peak height of the adamantane was found to fluctuate widely between cultures, type of crude oil used, and length of experiment. This was thought to be due to sublimation effect. Pristane, a branched hydrocarbon found as a natural component of both Louisiana and California crudes, was relatively inert to microbial oxidation during our experimental time periods and thus was used as a standard.

Figures 5 and 6 are chromatograph tracings of undegraded (control) Louisiana crude, and the same oil after being acted on for 48 hours by the SOCLA (oil positive culture). The graphs clearly show the decrease in straight chain paraffins due to continued microbial oxidation. There is a loss in the degraded sample of compounds below C-10, and a marked decrease in the peak heights of the straight chain paraffins from C-10 to C-20,

Figures 7 and 8 show undegraded and degraded California crude (E-76). Results are similar to those of the SOCLA culture on Louisiana crude except for additional peak height decreases in the C-20 to C-25 normal paraffins.

Figure 9 shows changes, resulting from microbial degradation, in peak height ratios, normalized to pristane, in the C-10 to C-19 straight chain paraffinic hydrocarbons. These cultures were grown on Louisiana crude. The TPLA culture significantly decreases the C-10 to C-19 straight chain hydrocarbons within the first 14 hours. The other cultures approach comparable degradation after 60 hours. Only the BHMO culture left significant amounts of C-12 to C-19 normal paraffins undegraded. However, it was very effective in dispersing the oil. One can easily see the decrease in normal paraffin components in the Louisiana crude oil with incubation time.

After gas chromatography procedure on controls and cultures, the residual crude material (corrected for that used in chromatography) was analyzed for total carbon by wet combustion. The oil was mixed with a sulfuric acid-dichromate solution, heated at 50°C for one hour, diluted 1:10 in distilled water and the per cent transmission of the resulting solution measured. This produced, as compared to known controls, the best quantitative method at present for determining rates of oil removal.

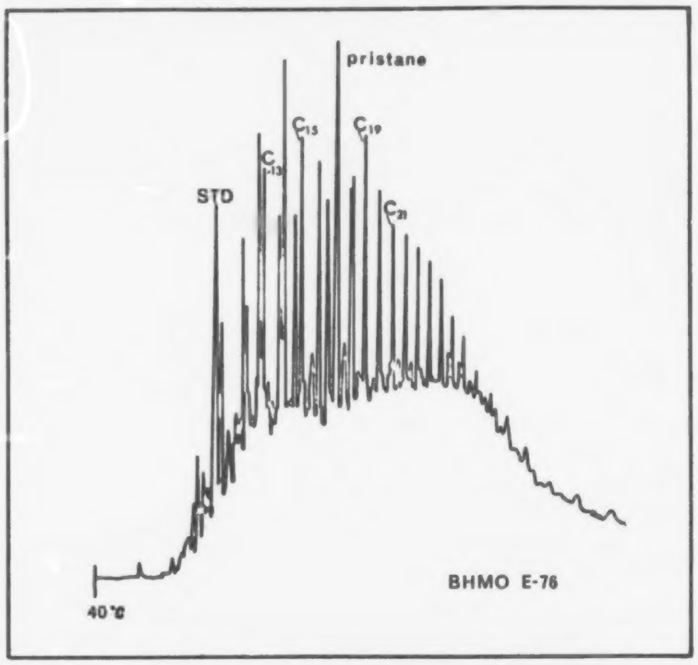

Figure 7. Gas chromatograph trace of undegraded California crude oil (E-76).

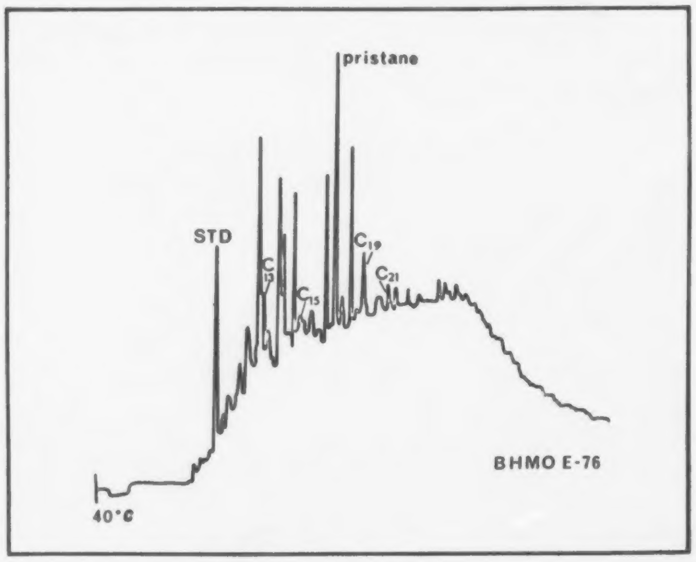

Figure 8. Gas chromatograph trace of California crude oil (E-76) (0.1% in 50 ml enriched seawater) after 72 hours degradation by microbial culture BHMO.

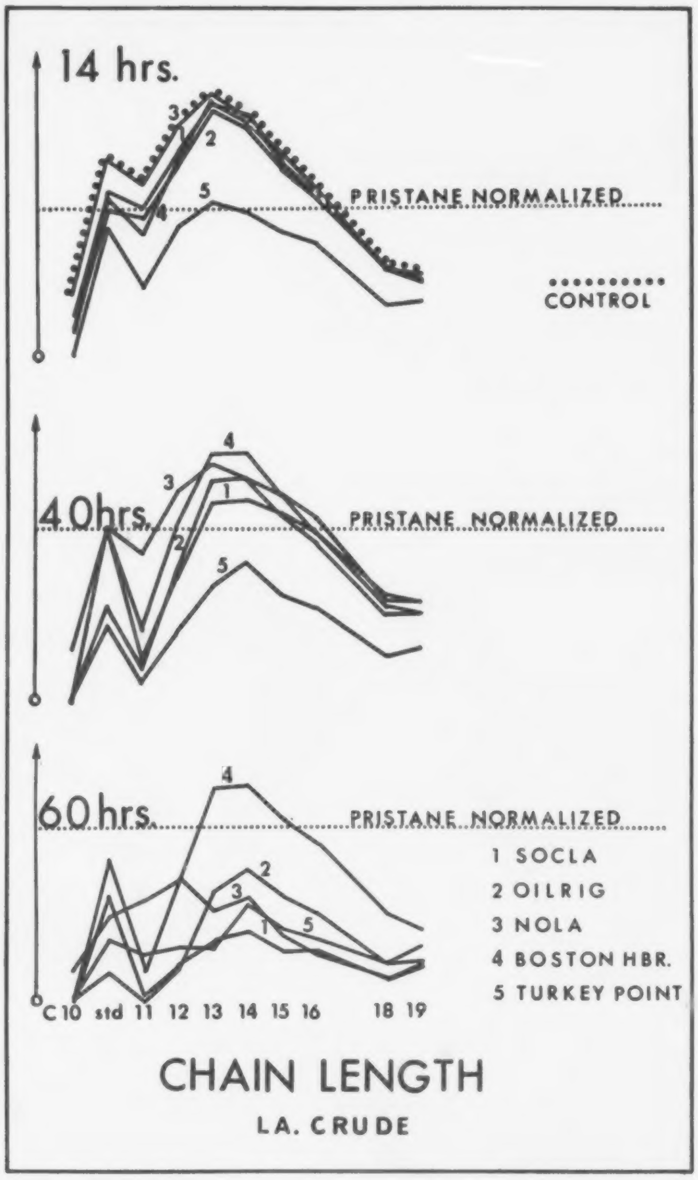

Figure 9. Changes in peak height ratios, normalized to pristance, of straight chain paraffins C-10 to C-19 due to microbial degradation of Louisiana crude oil.

Table 2 shows the per cent of dichromate oxidizable carbon in Louisiana crude oil remaining after 60 hours degradation by five cultures. NOLA (oil positive) has a lag period of approximately 24 hours before it begins to actively degrade the oil. After 60 hours most cultures had degraded from 40 to 50 per cent of the dichromate oxidizable components in the crude oil. These values are in agreement with similar experiments reported by others (4).

TABLE 2. WET COMBUSTION

Percent Louisiana Crude Oil Degraded

Sample	14	40	60
	Time (Hours)		
SOCLA	13	40	50
NOLA	0	15	35
OIL RIG	13	37	41
TPLA	29	47	55
BHMO	22	32	41

1. Determined by $K_2Cr_2O_7$ oxidation of residual crude oil after benzene extraction.

Conclusion

Fifty mixed cultures of active hydrocarbon degrading marine microorganisms have been isolated. Six of the cultures were studied for their ability to degrade crude oils. Most were shown by gas chromatography to readily oxidize normal paraffins up to C-25. Thirty-five to fifty-five per cent of the dichromate oxidizable crude oil was utilized within sixty hours in enriched seawater. Emulsification of the crude oil occurred in most cultures. A chemostat approach is indicated to determine proper rates of oil removal.

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Kinetics Of Dissipation And Biodegradation Of Crude Oil In Alaska's Cook Inlet

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Abstract

The results of a study to quantitatively define the magnitude of oil pollution problems in Alaska's Cook Inlet are reported. Physical dissipation and biodegration rates were determined and combined with estimates of hydrocarbon input rates to assess the fate of oil in Cook Inlet. The question of accumulation of crude oil components within the Inlet is considered from the above results and by direct analysis. Results indicate that hydrocarbon accumulation is less than our present limits of detection. Cook Inlet flushing is 90 per cent complete in 10 months. Experimental results show that unsupplemented Cook Inlet water effectively degrades Cook Inlet crude, that this biodegradation is essentially complete in the order of a few months, and that the biodegration capacity of Cook Inlet is large. Thus biodegration is more important than physical flushing in removing hydrocarbon pollutants from Cook Inlet. The methods and results are discussed in terms of their applicability to other areas.

Cook Inlet (Figure 1) is a major estuary located in southcentral Alaska. The inlet itself is approximately 150 n miles long and 50 n miles wide at the mouth. The estuary is naturally divided north and south into two regions by the topographic features of the West and East Forelands. Two major extensions exist at the head of the inlet, Turnagain Arm which is 43 n miles long and Knik Arm which is 45 n miles long. The bottom of the inlet is extremely rugged and bottom sediments are sand and gravel. Mud flats exist along the north and west shore. The average depth of the inlet may be taken as 300 feet at the mouth, 120 feet near the forelands, and 60 feet near the head. Knik Arm averages 50 feet for about half its length and then rapidly shallows to a large mud flat. Turnagain Arm shallows within the first 10 n miles to large mud flats cut by many tidal channels.

Tides and tidal currents are large.[1] The mean diurnal tidal range varies from 13.7 feet at the mouth to 29.6 feet at the City of Anchorage on Knik Arm. High velocity tidal currents are associated with these extreme tidal height differences. In the region of the forelands, velocities reach 3.8 knots and elsewhere, above these narrows, maximum velocities are in the range of 2.8 to 3.0 knots. In local areas velocities can be in excess of 5 knots. Large sheets of ice move back and forth with the tides during the three winter months.

Cook Inlet is a multiple-use estuary supporting large commercial fisheries, industrial and shipping usage, and extensive wildlife resources. Salmon, halibut, and crab are the more important commercialized fishery resources. Salmon and clams form the basis of recreational fishing. Additional wildlife resources include seal, beluga whale, ducks, geese, swan, and other waterfowl. Major oil industry related installations in Cook Inlet are shown in Figure 2. Offshore oil and gas wells are located from fifteen offshore platforms concentrated immediately north of the forelands. Underwater pipelines carry the oil to gathering facilities at East Forelands, Granite Point, and West Forelands where co-produced water is removed. From there, most of the oil goes to pipeline terminals for tanker shipment. Kenai Pipeline Terminal is located at East Forelands and the Cook Inlet Pipeline terminal is located at Drift River on the west shore.

Refineries and petrochemical plants are located at East Forelands and include the Standard Oil Refinery, Phillips Liquified Natural Gas Plant, Collier Chemicals Ammonia

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This paper is Contribution No. 61 of the Institute of Marine Science, University of Alaska, College, Alaska.

[1] Superior numbers refer to literature references at conclusion of text.

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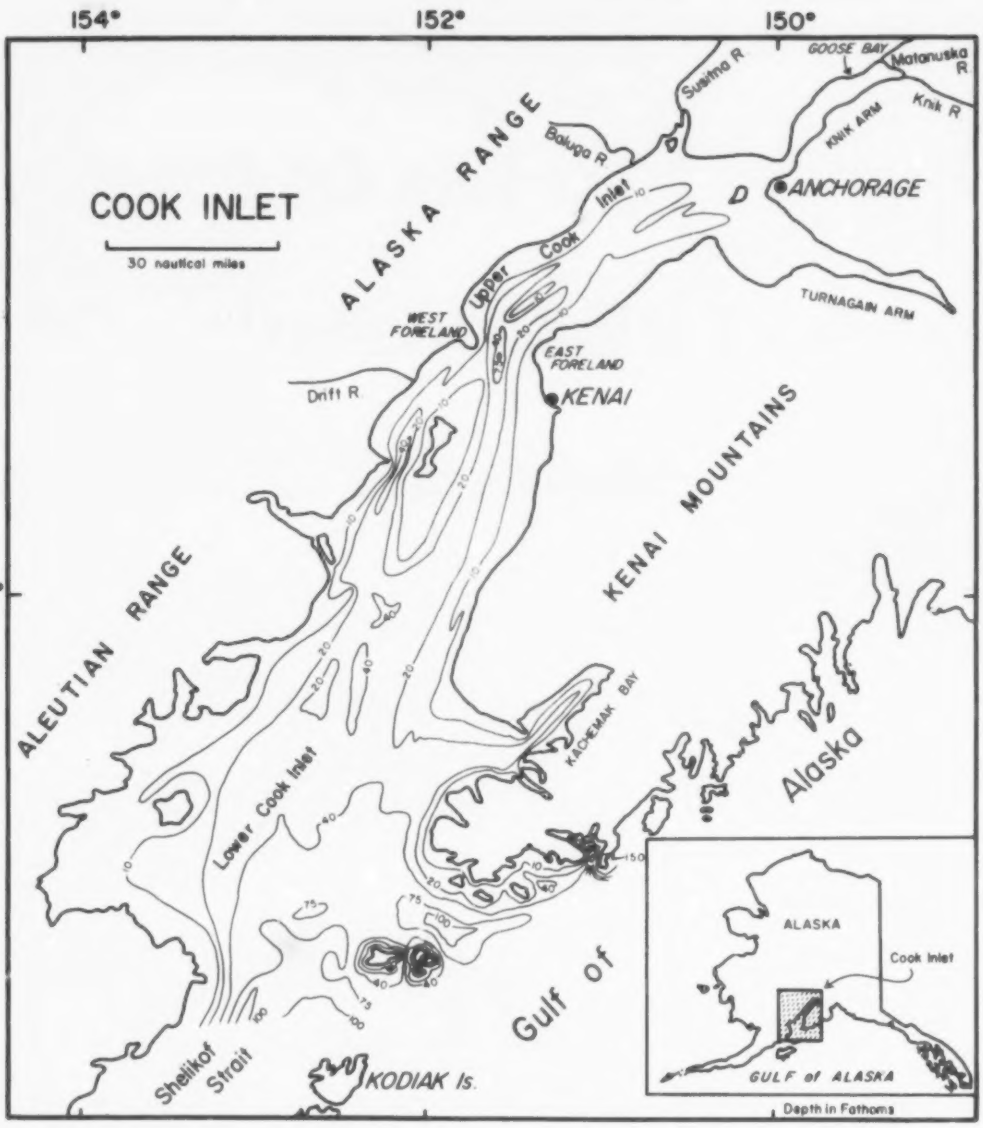

Figure 1. Map of Cook Inlet, Alaska.

Plant, and the recent Tesoro Refinery. The purpose of the present study was to quantitate Cook Inlet oil pollution in a manner that would furnish numbers to guide both industry and government. A secondary purpose was to develop both methods and results on the behavior and effects of petroleum in natural waters that would be of general applicability. Basic to this second point was the hope of a better method of monitoring pollution than the traditional, statistical inference of causes from difficulty measured biological damage. This latter approach is difficult in that continuous biological monitoring must be done wherever a pollution threat exists. More importantly, the questions needed to solve the pollution problem need to be answered with data on the specific mechanisms involved.

Three questions pertinent to oil pollution of natural waters need quantitative answers:

1. Fate of Oil:
   Upon entering the water, where does the oil go, in what concentrations and compositions versus time and place?
2. Toxicity:
   Given the information of 1. what are the specific physical or biochemical toxic mechanisms of damage?
3. Treatment of Spills:
   Based upon firm knowledge of 1. and 2., how should a major spill be treated to minimize damage?

Progress must of necessity be measured in relation to these vigorous goals of ultimate solution to oil pollution. The bulk of the present work is addressed to the first question, the beginning, but the results have implications for topics 2. and 3.

Consider Cook Inlet to be an open system 150 n miles long, 50 n miles wide at the mouth, with a total volume of 1.7 x $(10)^{13}$ ft.^{3} Consider the fate of oil question initially as an oil material balance about the Cook Inlet system. The rate of oil accumulation must equal the rate of input minus the rate of output and minus the rate of consumption thus:

Accumulation = Input - Output - Consumption

We have tried to elucidate all the mechanisms affecting each term of the above equation and tried to measure their corresponding rates.

Results

Input. The input term can be considered to be the unknown for which the equation is to be solved. However, an estimate by independent means is most helpful at this time as a check on the magnitude of the other terms. To estimate the order of magnitude of the accidental input term, data available was obtained from Federal and

State sources for years 1966, 1967, 1968, and 1969 on oil sightings in Cook Inlet gathered on:

1. random flights, and
2. flights following reports by industry and others.[2]

These data were combined with data on the amount of oil per unit areas of slicks (100 gallons/miles,^{2} 3 hours old, and 30 gallons/miles,^{2} 8 hours old), from measurements made on a large pipeline incident, and from a small experimental spill. Work was done from a Dehaviland Beaver float plane. In the case of the experimental spill, 20 gallons of Cook Inlet crude were poured on the water in the region of the forelands and were followed for a day by measuring and sampling from the air and on the water. The results of combining the above data indicate an input term of 2,000 - 10,000 bbl/year, almost all of it in the form of large, reported accidental incidences. The contribution from random sightings on a yearly basis ranged from 20-300 bbl/yr. The waste water from routine process streams discharged into the inlet from platforms, terminals, gathering facilities, and refineries and petrochemical plants contribute about 7,500 bbl/yr. of oil. This total input of 9,500 - 17,500 bbl/yr. corresponds to approximately 0.03 per cent of the total oil produced or handled in Cook Inlet.

Output. One important output term is due to the physical flushing of the estuary. The Cook Inlet estuary can be classified[3] according to physical circulation deduced from salinity distribution. Surface salinity and temperature distributions (Figures 4 and 5) along with detailed depth profiles presented elsewhere,[4] show that Cook Inlet can be typed as a two-layer flow estuary with intense vertical mixing which approaches a vertically homogeneous estuary with lateral variation due to coriolis force in the region north of Kalgin Island. An overall analysis of mixing in an estuary, in order to estimate the rate of removal of a pollutant introduced into it, is usually done by using fresh water as a tracer. Flushing of an estuary depends on the river input rate and salt water replacement rate due to mixing entrainment. A simple salt balance yields the following expressions assuming steady state:[3,5]

$$R(O) + V_1(S_o) = (R + V_1)S_a \tag{1}$$

or

$$V_1 = \frac{RS_a}{(S_o - S_a)} \tag{2}$$

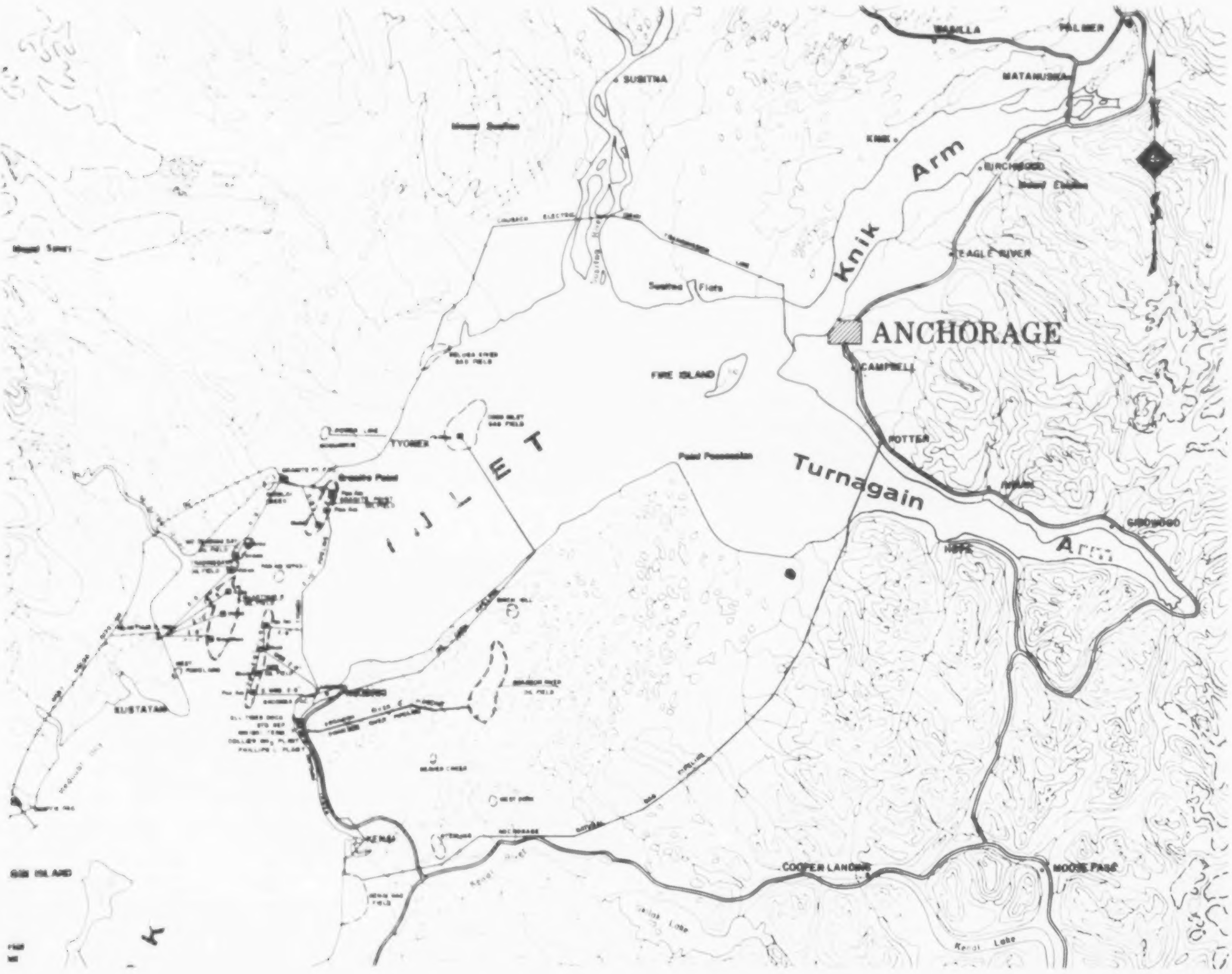

Figure 2. Major oil industry related installations, Cook Inlet, May 1968.

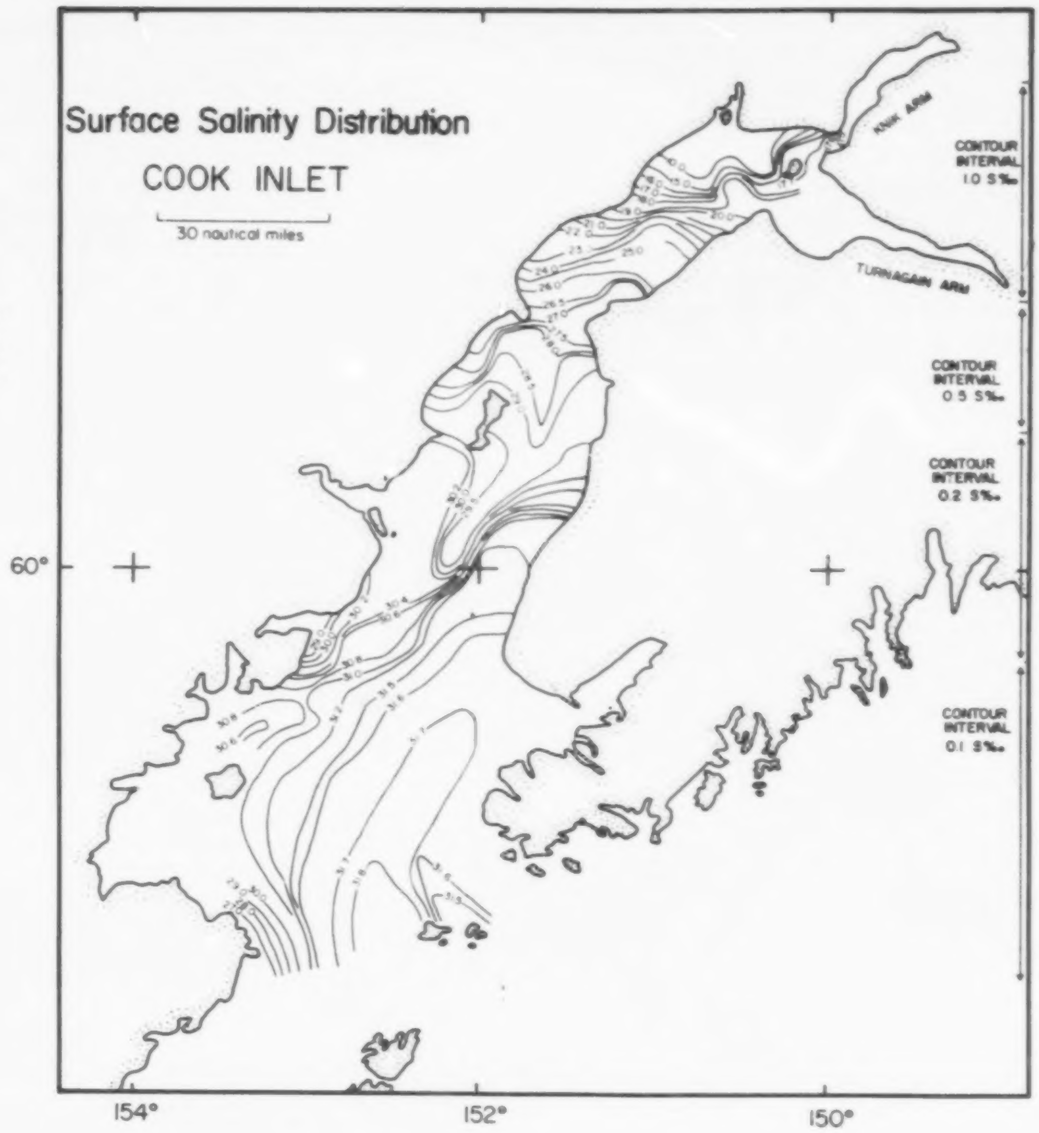

Figure 3.
Surface salinity distribution,
Cook Inlet, May 1968.

Where R is the fresh water flow rate into the estuary, S_o is the salinity of the saline source water at the mouth (at depth), V_i is the rate of salt water inflow due to entrainment, and S_a is the average salinity of the estuary. Using June salinity and river flow data[5] values of S_o=32.0 per cent, S_a=29.7 per cent and R=1.02(10)^5 ft.^{3}/sec. were obtained. Using these values in the salt balance equation, the value of V_i=1.32(10)^6 ft.^{3}/sec. is obtained which is equivalent to 4.40 (10)^{13} ft.^{3}/yr for the total input term $(R+V_i)=F$. Winter time river flow rates are only 5 per cent of this June value which would vastly decrease the flusing flow if the salinity distribution were constant. This reduced flushing would be effective for approximately half the year. However, Bowden[3] states that flushing times are not a strong function of seasonal river input variations based upon seasonal analysis of other estuaries. Since in Cook Inlet, tidal turbulence, independent of season, is a major factor in salt transport up the estuary, the V_i term would be expected to remain high. The very limited winter salinity data available also indicate a significant increase as would be expected. Therefore, using the above figures the approximate time for an introduced pollutant to be reduced to 10 per cent of its original concentration by flushing is given by the following expression with V being the total inlet volume:

$$t_{90\%} = \frac{(V)}{(R + V_i)} \ln 10 = 10 \text{ months} \tag{3}$$

Similarly an oil material balance

$$V\frac{dc}{dt} = I - Fc \tag{4}$$

Where I is the yearly input of crude oil and c is the resulting crude oil concentration in the water, results in a steady state crude concentration of 0.82 to 1.5 μg/ℓ based upon yearly inputs of 9,500 to 17,500 bbl/yr. (1 μg/ℓ = 1ppb) Time to reach 90 per cent of the steady state value would be approximately one year, starting from a zero concentration.

Output due to evaporation was determined by field measurements because of the difficulty in simulating air-sea interaction and interfacial emulsion properties in the laboratory. Two sets of measurements were performed with similar results. One involved sampling oil surfacing directly above the Santa Barbara leak and comparing the gas chromatographic spectrum with samples removed from the spill. The second involved sampling a small experimental spill of Cook Inlet crude in Cook Inlet over a period of one day by use of a float plane. Average wind speed throughout the day was 9-12 knots for this experimental spill.

Results of the latter experiment, shown in Figure 5, show that compounds below about C_{12} are significantly reduced in 8 hours. This reduction was presumably chiefly due to evaporation, although solubilization of the lower molecular compounds in the water phase also occurs. From these results, the major fate of gasoline and kerosene fractions is probably evaporation to the atmosphere, with gasoline being essentially gone in 8 hours. For light refined products or for crude oils with significant fractions in this boiling point region (e.g. Cook Inlet crude), this mechanism can thus be important in significantly reducing the water pollution.

Consumption. The major petroleum consumption term is microbial oxidation to CO_2 and H_2O. Field and laboratory observations were made in order to understand the mechanisms and rates involved. Repeated aerial observations of both small experimental spills and large accidental spills indicated the apparent half life of a surface crude oil slick in Cook Inlet was less than a day. Even in the case of a 1,000 bbl. pipeline break, the oil had completely disappeared from the surface in 3-4 days. Laboratory results show that the microflora excrete effective emulsifying agents which help the process considerably. Of course the great turbulence of Cook Inlet, driven by 20-30 foot tides and up to 5 knot currents, is a major factor.

Microorganisms capable of oxidizing crude oil can be found throughout Cook Inlet. Plate counts and most probable number determinations show populations of approximately 10^4 organism/liter with approximately 10 per cent of this population capable of utilizing crude oil. Of interest is the fact that a significant number of oil oxidizing microorganisms enter into the oil phase, rather than remaining in the aqueous phase and working on the surface of oil droplets. Particles of water in oil emulsion, mixed down into the water phase are literally micro-environments, being oxidized by microorganisms existing in both phases. These particles are more dense than sea water due to the presence of oxidized cell material and biomass and oxidized hydrocarbon intermediates. However, moderate turbulence keeps these particles in suspension.

Several microorganisms were isolated and found to use kerosene as the sole source of carbon. Chromatographic analysis indicated that various species selected different components from the hydrocarbons for their carbon and energy sources. Maximum growth rates ranged from 0.02 g cells/ g cells/ hr. in a mineral salts kerosene medium to 0.35 $hr.^{-1}$ on a complete medium.[4] These rates are reduced by a factor of 7 at 5°C, the prevailing summer temperature of Cook Inlet (Figure 4).

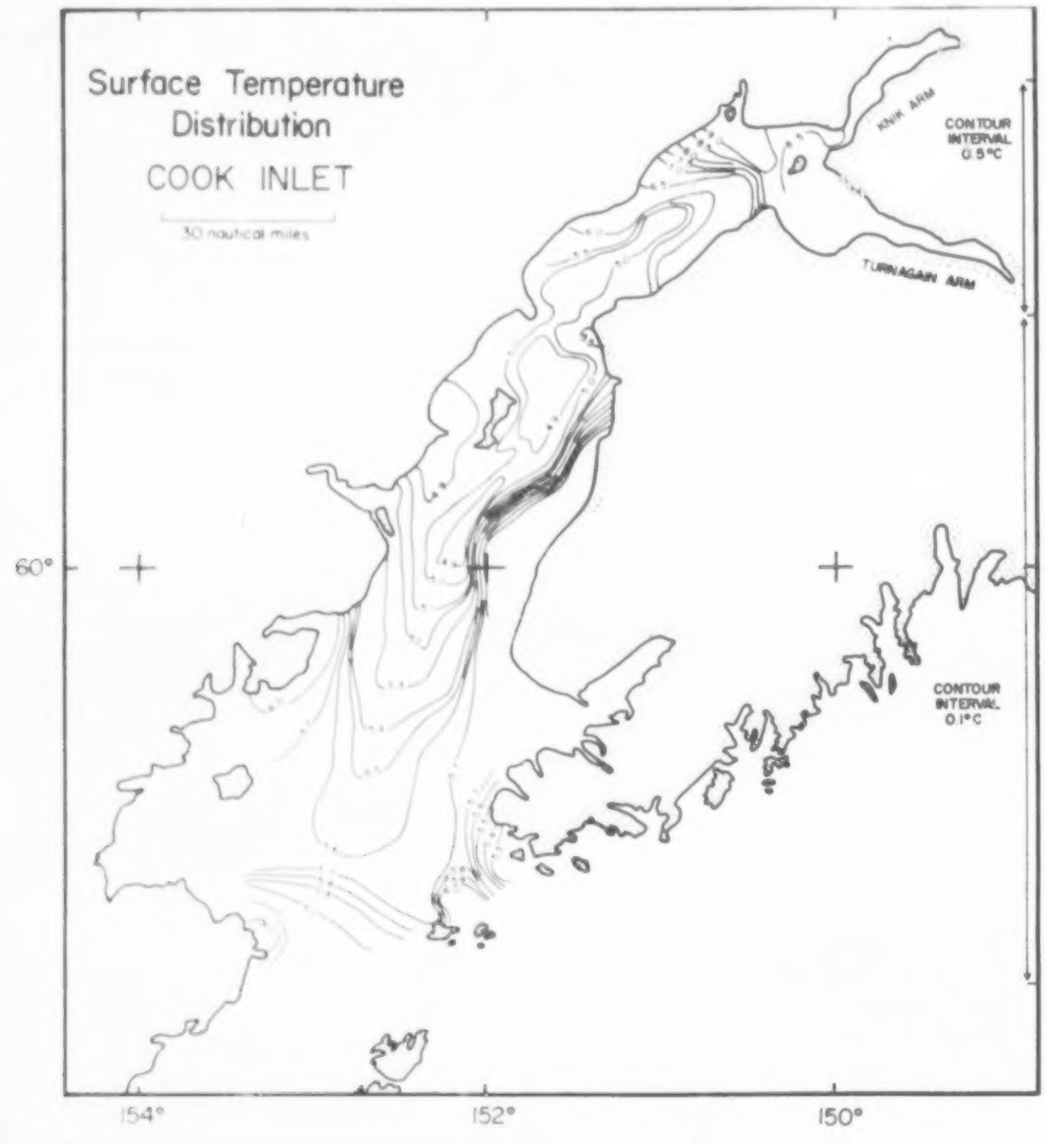

Figure 4.
Surface temperature distribution, Cook Inlet, May 1968.

For dilute populations in the sea, the supply of growth factors is probably adequate, particularly at low temperatures where growth rates are low with respect to diffusion transport. Nitrogen and phosphorous are in excess so that, barring increased inhibitor effectiveness at these low populations by species such as heavy metals, growth rates probably approach those in a complete medium. At this rate a 1000 fold population increase would require 5.7 days and complete oxidation of a 1 mg droplet of biodegradable oil would require 17 days after inoculation by a single bacterium. Populations in sterile bottles filled with Cook Inlet water and supplemented with autoclaved Cook Inlet crude oil were 10^9 per liter after 5 days at 10°C which is in agreement with the above growth rate and initial populations, assuming the success of collisions between the initial population and the oil was extensive during the first day.

Degradation of the heavy crude is probably slower than that of the fraction below C_{25}. Rather heavy artificial slicks confined in a carboy were rich in normal hydrocarbons above this size after two months' incubation with a mixed culture. Degradation of lesser concentrations of crude, 20 mg/l, appeared to be essentially complete after two months at 10°C and less than 5 per cent could be recovered at the end of one year. Artificial slicks on sea water surfaces in stirred carboys were clearly different in inoculated and sterile carboys at the end of three days, and degrading slicks broke up at the end of ten. The presence of silt appeared to have no effect on the process but mixing was extremely important. Slicks in completely unmixed carboys were very stable even when inoculated. Thus it appears that naturally occurring slicks are rapidly inoculated and broken up during the first day after a spill in the very turbulent Cook Inlet. Biodegradation then proceeds first in the micro-environments of the water in oil emulsion, later in the oil drops, and is probably essentially complete in one to two months and certainly before surrounding water is flushed out of the inlet.

Ultraviolet oxidation of crude oil is estimated to be negligible compared to biodegradation and flushing because of the low radiant energy input and the short half life of a thin surface film of oil. However, few data exist on this mechanism.

Accumulation. Independent estimates of the accumulation term were attempted by direct chemical analysis for hydrocarbons in the existing water and sediments of Cook Inlet. Experimental work is also in progress on two other independent methods using ^{14}C radiocarbon[6] and ^{12}C ^{13}C stable carbon isotope[7] analysis of dissolved and particulate organic matter from Cook Inlet. A carbon recovery apparatus[8] based on ultraviolet oxidation of the organic matter in sea water is in use for the ^{14}C measurements. Natural carbon in Cook Inlet and Cook Inlet crude seem to have nicely separated $^{12}C/^{13}C$ ratios. We do not at present have enough data to make conclusions from these latter two experimental results.

Direct chemical analysis for hydrocarbons from water and sediments was by gas chromatography preceded by an extractive concentration step. A considerable body of knowledge on the origin of petroleum and the migration in reservoirs[10-20] shows recent sediment C_{20}-C_{33} n-alkane concentrations to be 10-70 μg/g dry weight. One reference[21] for surface waters shows concentrations from 0.2 to 3.8 μg/l and two sea water samples at less than 0.2 μg/l total C_{20}-C_{33} n-alkanes. Blumer[9] has identified by gas chromatography, the presence of C_{14} to C_{33} straight chain hydrocarbons, branched paraffins at an order of magnitude less concentration, isoprenoid hydrocarbons, and at least two olefinic hydrocarbons (squalene and a polyunsaturated derivative of heneicosane). No concentrations or spectra are given. Thus the knowledge of natural hydrocarbons in aqueous systems is very limited; however, it is known that they are present and that their concentrations are extremely low.

In the present work, four liters of water, sampled with a large volume sampler of glass, stainless, and teflon, was extracted three times with pre-purified n-pentane and the extracts combined to 500 ml. Evaporation at 36°C with a small reflux condenser reduced the volume to approximately 1 ml. Silica gel chromatography[9] was used to isolate saturated hydrocarbons and the isolate in pentane was evaporated to a fraction of a ml and injected into a temperature programmed gas chromatograph equipped with a flame ionization detector. A fifty foot 0.025 inch diameter open tubular capillary column with 5 per cent OV-17 on the wall coating support was used Detection limits as determined by internal standards was of the order of 0.02 μgm/l for individual hydrocarbons in the C_{10}-C_{25} molecular weight range or about 20 μg/l of Cook Inlet crude. Analysis of samples of water and suspended sediments from 70 stations distributed throughout the Inlet showed completed negative results to the detection limits quoted above. Thus these results indicate that the Cook Inlet system is not grossly polluted by hydrocarbons. However, the present detection limits do not allow an independent estimate of the relative effectiveness of flushing and biodegradation. Work is continuing on improving these detection limits by one or two orders of magnitude by eliminating the sample splitter for the open tubular column or by use of conventional columns.[21]

Data on light gas analysis (C_1-C_5) showed indicated possible minute leakage from the reservoir structures; however, the amounts involved are infinitesimal in terms of hydrocarbon pollution. Accumulation of microbiologically fractionated refractory compounds appeared to be negligible and is discussed in C above and elsewhere.[4]

The possible buildup in Cook Inlet of toxic transition metals from crude oil pollution was considered. If the highest value from above for the crude input is assumed and combined with the general ppm concentrations of trace metals in crude, then the steady state level of trace metal concentrations due to oil input is limited by physical flushing to a value three orders of magnitude below natural levels. Thus this danger does not seem to be a real one in Cook Inlet. Also, our biodegradation rates run with Cook Inlet crude, would consider localized concentrations of trace metals effecting these rates.

Discussion

Major effects of accidental spills on the environment of Cook Inlet are not clear. Certainly spills would have little effect on the water chemistry such as carbon, oxygen and nitrogen which are usual indicators of pollution. The more important effects of a large spill might be reduction of the

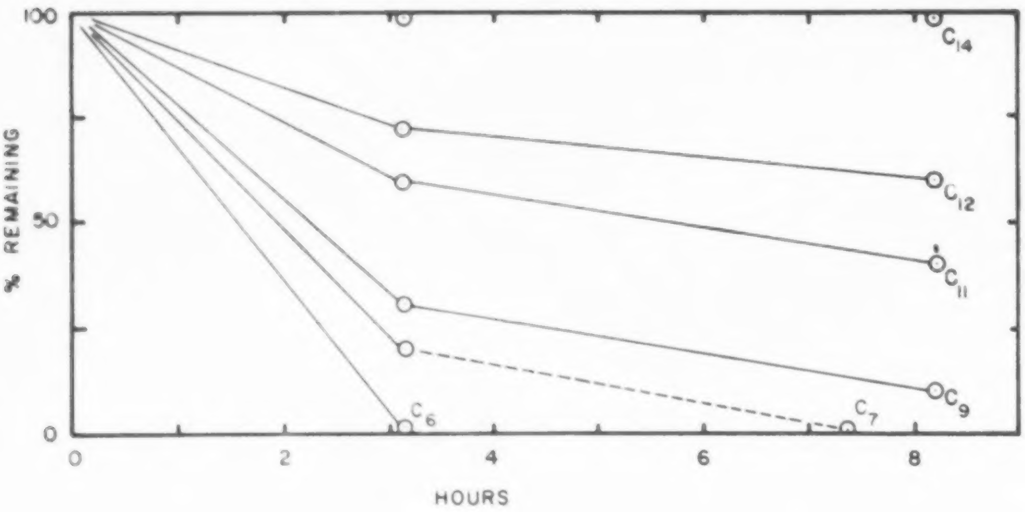

Figure 5.
Evaporative loss of low molecular weight hydrocarbons in an experimental spill of Cook Inlet crude in the forelands regions of Cook Inlet.

aesthetic quality of beaches, fouling of fishermen's gear and oiling of water fowl. Continuous oil slicks on the surface are probably of more concern than similar quantities of oil dispersed below the surface. Only at the surface does oil contribute to the aforementioned problems.

Aside from prevention, no technology exists to substantially minimize damage from a large accident. Recognition of biodegradation as the fastest process in removal of hydrocarbons from Cook Inlet has implications for the treatment of oil spills. For example, detergents might be designed to act in concert with this process.

Given potentially high rates and capacity of the biodegradation mechanism methods of sinking oil spills into the water column may well be practically, as well as ecologically, attractive. The large quantities of Cook Inlet sediment available might be investigated as a type of vehicle, after proper treatment, to do this.

Some of the information gathered here is applicable elsewhere. For example, biodegradation appears to be a significant low temperature process. Lack of mixing is a significant hinderance to this mechanism. Hence, a potential oil spill problem area, such as the Arctic, should be investigated in terms of the physical stability of oil in pack ice and in the comparatively poorly mixed surface waters. The biodegradation mechanism should be assessed under these conditions.

Conclusions

1. Estimated input of petroleum hydrocarbons from accidental spills and effluents is approximately 10,000 to 17,000 barrels per year or approximately 0.03 per cent of the total produced and handled in Cook Inlet.
2. The half life of an oil slick on the surface of Cook Inlet is less than a day.
3. Tide driven turbulence is the chief factor in breaking up oil slicks on the surface of Cook Inlet.
4. Generally, strong tidal currents and their geometry tend to keep oil which has been spilled out in the inlet away from beaches, with the exception of Kalgin Island.
5. A microflora of hydrocarbon oxidizing organisms exists at a concentration of about 10^3/l which functions as an inoculum and suggests the present of transient hydrocarbons.
6. Biodegradation of Cook Inlet crude oil in Cook Inlet is essentially complete in one to two months.
7. Tidal and river driven flushing reduces Cook Inlet components within the inlet by 90 per cent in about 10 months.
8. Evaporation effectively removes components smaller than about C_{12} within 8 hours.
9. Accumulated petroleum hydrocarbons in the range C_{10}-C_{25} were below the limits of detection, 0.02 μg/l, in Cook Inlet waters and suspended sediments. Trace transition metals from crude oil were found to be limited by physical flushing to levels three orders of magnitude below natural levels.

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Movement Of Oil and Water In Santa Barbara Channel, California

Dr. Ronald L. Kolpack
Research Associate
University of Southern California

(Manuscript not available for publication)

Conference Summary

C.G. Cortelyou
Cordinator, Air and Water Conservation
Mobil Oil Corporation

and

H.A. Bernard
Chief, Agricultural and Marine Pollution
Federal Water Pollution Control Administration

Summary

The most significant and surprising aspect of this Conference was the fact that eleven hundred people–about three times what had originally been anticipated–came to exchange information on the crucial topic of oil spill prevention and clean-up.

Conservationists, pollution control officials, petroleum industry representatives, university scientists and equipment manufacturers all made a contribution, and all came away with new information and ideas.

One of the most important lessons learned was that while the information exchanged was the most advanced thinking on the subject, there is still a long way to go. The body of knowledge is growing rapidly–but the unknowns still outweigh the knowns.

A sketch of the dimension of the problem was drawn in the opening session by K. E. Biglane of FWPCA. He pointed out that we are approaching a frequency of 10,000 oil spill incidents a year. About two-thirds of them are in port and harbor areas and are generated in routine petroleum transfer operations. And while bigger spills are the ones that make the headlines, it is the smaller more frequent accidents which may, in the long run, place the severest burdens on our ecological systems.

The Conference heard reports on contingency plans–both those developed by the federal government and those developed by the petroleum industry.

Cooperative efforts for spill clean-up have been formally established in 23 U.S. port areas and plans for other cooperatives are being drawn up in an additional 27 areas.

Several federal agencies are conducting broad research programs on the containment, recovery and treatment of oil spills. To date, the American Petroleum Institute has allocated \$1¼ million to oil spills cleanup research. This is only a small part of total industry effort. Individual companies, of course, are carrying out extensive research of their own. Government and industry are working closely together to assure that their programs complement one another.

United Kingdom representatives outlined research being carried on there by both the petroleum industry and various Ministries of the Government. The use of chemical dispersants on the Cornish Coast following the *Torrey Canyon* spill caused damage to marine and plant life in the intertidal zone. A number of petroleum industry representatives expressed similar cautions concerning the use of toxic substances in intertidal zones or in shallow areas where harm to marine life–and fish harvest potential–is likely to occur. It was noted, however, that fish catches in the area of the *Torrey Canyon* showed no long-term decrease.

One of the more promising techniques for the dispersion of oil slicks, according to U.K. representatives, is the use of sand slurry sprayed on the slick. Reported on, too, by this group was work done on the burning-off of petroleum as a possible means of disposal from wrecked tankers. The use of booms for containment was also discussed extensively with the general conclusion that they are presently ineffective in any sort of chop or swift current, although they may be of considerable help with smaller spills encountered in calm areas.

Considerable work carried out by the U.S. Coast Guard in regard to parameters for boom design was

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INTERSTATE RELATIONS COMMITTEE

PROBLEM: Determine the mechanisms needed to develop and maintain reciprocity between States.

Richard M. Fry, Kentucky, Chairman

Ira Paul Leggett, Jr.	District of Columbia
Sadamoto Iwashita	Hawaii
Donald C. Hoxie	Maine
Eddie S. Fuente	Mississippi
Gene A. Christianson	North Dakota
J. Dale McHard	Oklahoma
Robert E. Sundin	Wyoming
Norman A. Geiger	BRH, Region III

MR. FRY: This committee met to summarize some of the areas of concern in interstate relations and specifically those related to the charge of reciprocity needed among States. A degree of conformity and compatibility within the regulatory program is necessary in order for this reciprocity to apply.

Mutual trust is needed as a basis for reciprocity. This is an understanding that other groups are operating in a manner similar and acceptable to the other parties involved. It is important not only in the way regulations are written but also that compliance and overall operations are acceptable to all.

In areas where no regulations exist, the key is cooperation and communication. In some cases, those involved in a reciprocity problem may be small in number. An informal arrangement of interchange of information is all that is needed in such cases. There is no need to write a national compact to cover all the States and territories involved if there are only a few groups involved. How can this cooperation be encouraged? It is helped through meetings such as this and others of similar nature and through continuing contact with each other. Another area of activity can be in the continuing operation of the committees set up for this meeting.

There does need to be a freer exchange of information, in some instances through a formal arrangement, in others in an informal manner. This exchange needs to be not only among States but among States and the Federal governmental agencies and communication within the Conference as well.

This committee has identified five areas in which we feel action is needed:

1. The first subject area of concern is the licensing of non-agreement material specifically related to radium distributors. This would be the licensing of non-agreement materials in non-licensing States. This is a new term that has been suggested rather than non-agreement States since we have two radium licensing States which are non-agreement States.

2. Another broad area of concern is in x-ray technician licensing and the reciprocity needs there. Howard Goldman from New York talked on the reciprocity arrangements which they are setting up with the States already involved with licensure. However, there is a real need for the cooperation and exchange of information long before legislation is adopted. If legislation is passed that is non-compatible with the rest of the licensing bodies, no matter how much you would like to cooperate, your legislation is out of step. Thus, this is the area for models and the adaptation of models to fit local needs.

3. Problems abound in existing x-ray facilities, those currently in the field and the exchange of used equipment. One specific area is Medicare certification and some of the problems of operations that cover more than one State and the need for cooperation as far as the standards and their interpretation is concerned.

4. Another area that was discussed is industrial radiography, the radiography companies themselves and the individual radiographers.

5. The final subject area of concern is with other electronic products and the needs that might arise.

It is obvious that a title of interstate relations was too broad for this meeting's operations. It became quickly obvious that the specific charge of the mechanisms needed to develop and maintain reciprocity was too large and that specific areas and critical need of reciprocity should be assigned to this committee for further work out of the five general ones covered in this report.

This committee turns to the Executive Board of the Conference to assign the specific areas where they feel the greatest need exists. The ongoing operations of this committee will be to deal specifically with the areas that would be thus assigned.

This report lists the five items covered, pretty much in the order with which we felt there was the greatest need, starting out with non-agreement material licensing, the second being the x-ray technicians, the third the existing x-ray facilities, fourth being industrial radiographers, and fifth, other electronic products.

PROFESSOR BLATZ: Are there any questions or comments for this report? The next committee is Standards, Regulations and Legislation, Martin Wukasch, Texas.

STANDARDS, REGULATIONS AND LEGISLATION COMMITTEE

PROBLEM: Recommend legislation needed for adequate State control of radiation hazards and review the existing models.

Martin C. Wukasch, Texas, Chairman

Donald C. Gilbert	Arizona
Leroy E. Stratton	Illinois
E. A. Fullgrabe, M.D.	Missouri
Wendell D. McCurry	Nevada
Aaron Bond	New Mexico
Joseph Wuraftic	Rhode Island
Bryce P. Schofield	Virginia
James A. McTaggart, D.D.S.	BRH, Region VII

MR. WUKASCH: Mr. President, Mr. Cochairman, Fellow Conference Members: The charge given our particular committee was to recommend in the area of standards, regulations and legislation the needs for adequate State control of radiation hazards and to review existing models.

Just as Dick Fry told you, we also had to conclude at the beginning of our session we had to establish some narrow bounds or we would be here a week or two. And even though our dedicated committee did give up a couple swim periods, we didn't want to bite off more than we could chew within the time allotted us.

I. Statement

A. Committee did not review x-ray technician licensing model legislation because bill is still in draft and should be available for review and comment by States in approximately two weeks.

The committee recommends that each recipient give this proposed bill profound consideration.

II. Recommendations

A. That the industries establish uniform training standards for installation and/or repair personnel concerned with their respective electronic products capable of emitting radiation.

B. That States use model regulations and legislation, as they are available, in development of programs to assure uniformity.

Reiterated and emphasized from last year. At the same time the BRH should give careful consideration to existing State regulations when formulating standards.

C. That all States adopt model regulations for x-ray control as available from the Council of State Governments to provide uniformity of inspections, compliance, and to facilitate the exchange of information necessary to insure such uniformity. (Such as descriptions of defective equipment and qualifications of industrial x-ray users.)

To expand upon that just a bit, I would like to add this parenthetically: We think benefit would occur between the States by exchanging such knowledge as we have on defective equipment and particularly the qualifications of industrial x-ray users.

D. Subsequent to the adoption of performance standards for electronic products by the BRH, it is recommended that model regulations be developed as soon as possible by the BRH, in cooperation with the Conference of State Radiation Control Program Directors, for control and use and users of such equipment.

Now, everything I have given you so far had unanimity among the committee members. The next item, the State of Virginia had a minority report. There was one vote against this so we will give you the minority report.

E. That legislation be pursued to give the USPHS authority to regulate and control radioactive material not currently regulated by the USAEC or an agreement. This was our semantics to try to cover both an agreement State and any State with which an agreement now exists through some other form.

The State of Virginia minority report was, "As a representative of the Radiological Health Program of Virginia, I do not feel that I can at this time support this recommendation as it is worded. (signed Bryce Schofield.)"

F. That the BRH assume leadership in developing uniform control programs for radiation protection for Federal agencies and installations not regulated by the AEC.

It is further recommended that those States so desiring may be delegated this responsibility on a reimbursable basis.

III. Recommendations to the Conference Executive Committee

That the BRH and the Conference pursue the establishment of funding, on a matching basis, for distribution and assistance to cooperating States as provided in Section 356, P. L. 90-602.

IV. General Recommendations

Because of the recommendation carried in Item II-C by our Committee, it is recommended that the Committee on Standards, Regulations and

Legislation be provided with a liaison member to the Interstate Relations Committee.

Therefore, this Committee relegated the assignment of liaison member to Mr. Jim Porter of Louisiana to assist on the interchange of information necessary to the implementation of our recommendation II-C.

PROFESSOR BLATZ: I should mention that there was one other committee, an ad hoc committee, set up just a short time ago to review and comment on the proposed performance standards for medical x-ray equipment. We had a few meetings. We have a long way to go, but we have been discussing several general principles.

We have discussed these informally with BRH representatives. And we made a strong plea that they try to avoid bureaucratic and legalistic jargon with which so many laws are filled, including the AEC Part 20. Some of us have some troubles with it. And we see creeping in, new words, for which we had perfectly good conventional old words.

Also, we made a plea for not being too ambitious in preparing performance standards. I was reminded of this in looking at my notes, I believe it was Congressman Rogers said that it should be possible to determine if a standard is being met. And I think this holds true here if a performance standard is set, it should be possible to go out in the field and determine without too much trouble whether it is being met.

The standards, therefore, should be standards that are capable of being met by the manufacturer without too great an increase in cost and standards that have been tried, tested, in the field.

We still think these are very broad ideas, and we have a great deal more work to do on this.

And I neglected, I think, to say that I was chairman of this particular committee.

Regarding committee reports, I would like to make a plea that each committee in reporting clearly state at the end what its conclusions and recommendations are. We will be getting quite a few reports which we hope you will all read. And I think at the end some specific conclusions and recommendations are appropriate.

I would also like to say about the committees it was suggested that they be set up as standing committees. I don't think any firm decision was made, but I think the committees themselves and the chairmen of the committees would be helpful if each would indicate any possible changes within their committees, if they have new members or members they have learned are particularly interested or competent in the field they are studying, and suggest the addition. There may be other members who from shortage of time or possibly interest have not been very effective. So changes within the committees, I think, are up to the chairman to recommend.

Also, as each committee is given a new particular problem, there may be another member of the committee who would be more appropriate to serve as chairman. I would like this to be reasonably flexible if it can improve the activities of these committees.

There has been a suggestion that perhaps we need a resolutions committee. This has not been acted on, but it is quite possible. And I thought as I heard some of the recommendations here that these might well suit as resolutions of the conference as a whole.

It has been suggested that we need good publicity. People have to know. I think we got very good publicity at this meeting. People have to know that we exist and what we are tying to do.

And I think the publication of resolutions in one way or another would be a good way of doing this.

The final and last item on our agenda is summary and closing comments by James W. Miller, Office of Regional Operations, Bureau of Radiological Health in Rockville.

SUMMARY AND CLOSING REMARKS

DR. MILLER: Thank you, Hanson. And welcome to the dubious honor of being Cochairman of this great body.

It has been my great pleasure to be your Cochairman this year. I have been really impressed with your dedication by your attendance, your attentiveness and the effort that you have put in to this. I really appreciate that.

I would like to apologize for part of the program. We tried to do too much in too short a time. There are so many areas that we have to cover and feel that are important to discuss. We just ran out of time in some instances and didn't have enough time for discussion. Hopefully, we will be able to eliminate that in future meetings.

It has been a step towards the excellence which we all are seeking. Individually, it may have been a small step, but I think it has been a giant step for radiological health.

I will not try to summarize the meeting again. John Villforth did that very adequately this morning.

If he were here, I believe he would agree 100 percent with most of the comments that were made by the various committees this afternoon and the priorities that you have placed on your various activities. He would also remind you that the Federal Bureau of Radiological Health needs help in the implementation of P. L. 90-602.

As long as we are in the process of developing standards for electronic products, we are going to have brush fires. A search and destroy type of operation will have to be carried out to take care of these. In doing this, we are going to be asking for assistance.

This does not mean that you should stop all ongoing programs and start large scale activities in the nonionizing area or in some electronic product areas which do not have as much public health significance as the activities you are currently carrying out. But if you can see your way to provide some assistance, when requested this will be greatly appreciated.

In my reading, I came across a quote by Jane Adams who said, "Progress is not automatic. The world grows better because people wish that it should and take the right steps to make it better. If things are ever to move forward, somebody must be willing to take the first steps and assume the risk."

In our quest for quality, we as the professionals in the radiological health field must take the first steps even if there are some personal risks at stake.

This idea of a resolutions committee is excellent. If you are to be recognized as the authorities in this area you have to establish a position on the controversial issues of the day. We cannot be wishy-washy when the protection of the public is concerned.

With that, I would like to close my remarks and thank you all for your attendance.

PROFESSOR BLATZ: Thank you, Jim. And, really, in closing, I would like in behalf of the Conference of Radiation Control Program Directors to thank the Bureau and particularly John Villforth and Jim Miller for making this meeting possible. We couldn't exist without them.

And I also think that they couldn't exist without us for very long. So I think it is mutual.

Thanks a lot, Jim.

So we will adjourn.

APPENDIX A

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PARTICIPANTS

Aaroe, William H.	New Jersey
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Church, James L.	Tennessee
Clark, Ulray	Florida
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Eldridge, W. T.	Florida
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---

*See page 338 for abbreviations.

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Lazell, J. Arthur	BRH
Lea, William L., Ph.D.	Wisconsin
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Leupold, Roger	BRH
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Lindsey, Fred	Tallahassee, Florida
Lineweaver, Jack	

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Rogers, Lester	Atomic Energy Commission
Rogers, Paul G.	U. S. House of Representatives (Florida)
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Trout, E. Dale, D.Sc.	Oregon
Valear, Peter	BRH
VanFarowe, Donald E.	Michigan
Veater, Joel G.	Kentucky
Velez, Amalia	Puerto Rico
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Wagner, William L.	Alaska
Wallace, K. K., M.D.	Norfolk, Virginia
Will, Robert C.	Kansas
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Wilms, Heinz G.	BRH
Wood, Valorie A.	BRH
Wukasch, Martin C.	Texas
Wuraftic, Joseph	Rhode Island
Wynd, James	Ohio
Zellner, Leon	BRH, Region V, Chicago, Illinois

BRH - Bureau of Radiological Health, Rockville, Maryland,20852
ECA - Environmental Control Administration, Rockville, Maryland,20852
NERHL- Northeastern Radiological Health Laboratory, Winchester, Mass.
SERHL- Southeastern Radiological Health Laboratory, Montgomery, Alabama
SWRHL- Southwestern Radiological Health Laboratory, Las Vegas, Nevada

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Miami Herald
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APPENDIX B

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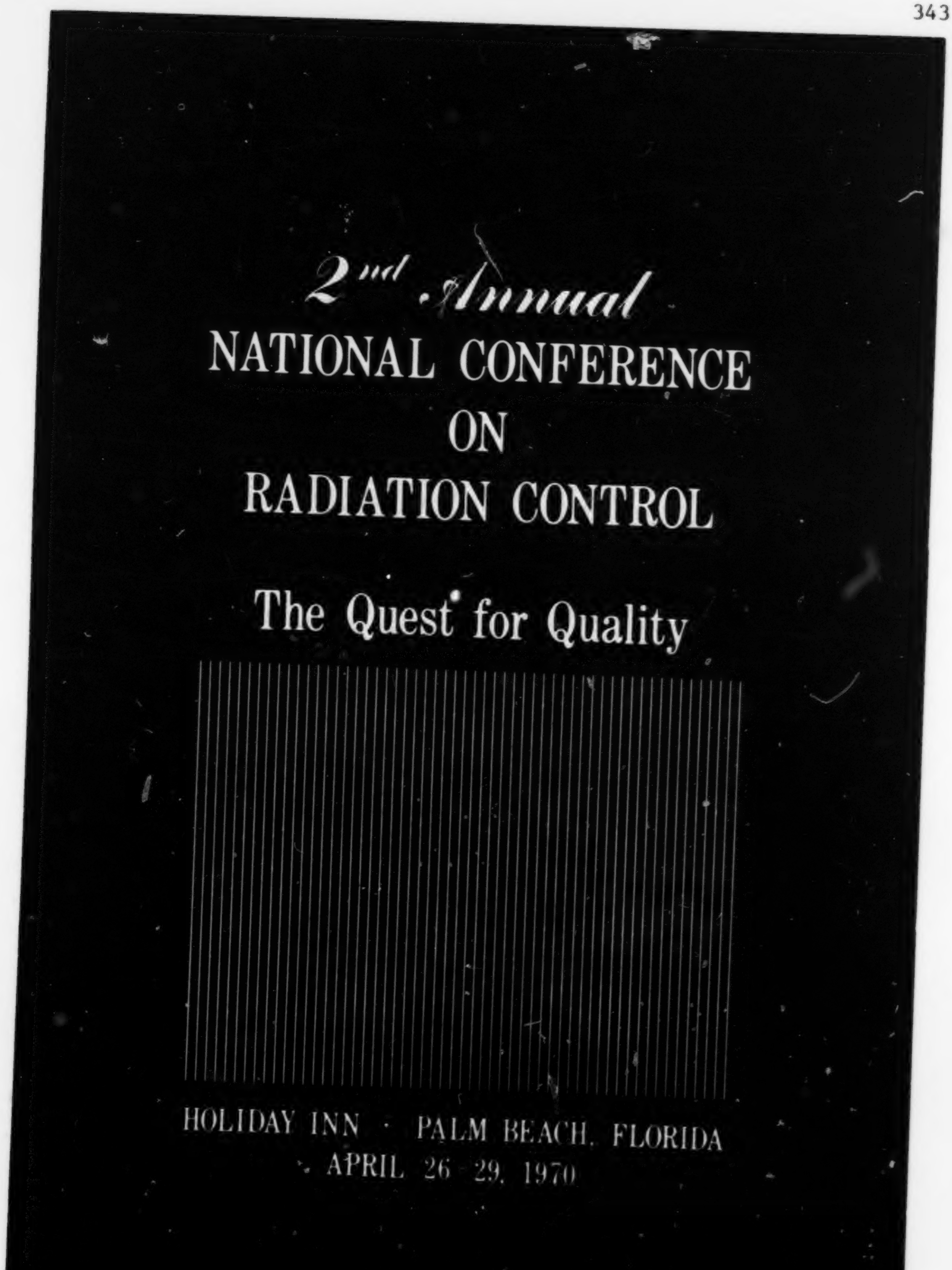

2nd Annual

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James W. Miller, D.D.S., Director
Office of Regional Operations
Bureau of Radiological Health

Proceedings will be published
and made available by the
Bureau of Radiological Health

SUNDAY, APRIL 26, 1970

12:00-3:00 p.m. - REGISTRATION - Upper Lobby

1:30 p.m. - Meeting of Committee Chairmen and Resource Personnel - Churchill Room

3:00 p.m. - OPENING SESSION - Churchill Room
Moderator: James W. Miller, D.D.S.
Bureau of Radiological Health

Welcome
James A. Bax, Ph.D.
Florida Department of Health
and Rehabilitative Services

The Challenge of Radiation Control
Honorable Paul G. Rogers
U. S. House of Representatives

Protecting the Public from Radiation
Jesse L. Steinfeld, M.D.
Surgeon General
U. S. Public Health Service

Accomplishments and Goals:

Federal Program
John C. Villforth, Director
Bureau of Radiological Health

State Programs
Thomas M. Gerusky
Pennsylvania Department of Health

5:15 p.m. - ATTITUDE ADJUSTMENT PERIOD
Poolside (weather permitting)

MONDAY, APRIL 27, 1970
CHURCHILL ROOM

APPROACHES TO THE CONTROL OF ELECTRONIC PRODUCT RADIATION

8:30 a.m. - ADMINISTRATION OF PUBLIC LAW 90-602
Moderator: Roy A. Parker, Ph.D.
Louisiana Board of Nuclear Energy

Activities, Plans, and Problems
Robert L. Elder, Sc.D.
Division of Electronic Products
Bureau of Radiological Health

Development of Standards & Regulations
Donald L. Snow
Office of Criteria and Standards
Bureau of Radiological Health

X-ray Performance Standards
William S. Properzio
Division of Electronic Products
Bureau of Radiological Health

10:00 a.m. - BREAK

10:15 a.m. - HEALING ARTS X-RAY CONTROL
Moderator: Simon Kinsman, Ph.D.
California State Department of Public Health

Establishment of Inspection Priorities
Richard M. Fry
Kentucky State Department of Health

Improving Technique
Joseph A. Brennan
New Hampshire State Department of Health and Welfare

MONDAY, APRIL 27, 1970
CHURCHILL ROOM

10:15 a.m. - HEALING ARTS X-RAY CONTROL (continued)

Regulatory Changes for Effective Programs
Hanson Blatz
New York City Department of Health

12:00 - LUNCH

1:30 p.m. - HEALING ARTS X-RAY CONTROL (continued)

Technique Trends in Radiology
Reynold F. Brown, M.D., and
Bruce Burnett
University of California

Evaluation of New X-ray Equipment
E. Dale Trout, Sc.D.
Oregon State University

Records Management
John W. Shaver
North Carolina State Board of Health

3:15 p.m. - BREAK

3:30 p.m. - COMMITTEE ASSIGNMENTS
Thomas M. Gerusky
Pennsylvania Department of Health

3:45 p.m. - PROBLEM SESSIONS

6:30 p.m. - ATTITUDE ADJUSTMENT PERIOD
Press Room (cash bar)

8:00 p.m. - BANQUET - *Cotillion Room*
1969 Miami Dolphins Football Highlights
Dick Anderson - Miami Dolphins

TUESDAY, APRIL 28, 1970
CHURCHILL ROOM

APPROACHES TO THE CONTROL OF ELECTRONIC PRODUCT RADIATION (continued)

8:00 a.m. - NONIONIZING RADIATION SOURCES
Moderator: Gerald S. Parker
Massachusetts Department of Public Health

Microwave Survey Instrumentation
Mays L. Swicord
Division of Electronic Products
Bureau of Radiological Health

An Overview of Diathermy Sources
Gerald J. Karches
Northeastern Radiological Health Laboratory

Repairmen of Microwave Sources
William M. Eden
Florida Department of Health & Rehabilitative Services

Lasers & Laser Hazard Evaluations
Harold F. Stewart, Ph.D.
Southwestern Radiological Health Laboratory

Radar Hazards Evaluation
Ronald L. Shearin
Southeastern Radiological Health Laboratory

10:00 a.m. - BREAK

TUESDAY, APRIL 28, 1970
CHURCHILL ROOM

10:15 a.m. - PANEL: USER QUALIFICATION
Moderator: Robert Frankel
Radiological Health Representative
Bureau of Radiological Health

Licensing X-ray Technologists
Richard Olden, R.T.
American Society of Radiologic Technologists

California Radiologic Technology Control Act
Simon Kinsman, Ph.D.
California State Department of Public Health

Reciprocity
Howard L. Goldman, LXT
New York State Department of Health

Model Legislation
Bobby L. Dillard
Office of Regional Operations
Bureau of Radiological Health

12:00 - LUNCH

TUESDAY, APRIL 28, 1970
CHURCHILL ROOM

NUCLEAR FACILITIES AND THE ENVIRONMENT

1:30 p.m. - PANEL: POWER REACTORS AND THE ENVIRONMENT

Moderator: Ernest D. Harward
Division of Environmental Radiation
Bureau of Radiological Health

The Environmental Controversy
Harry B. Ashe
Vermont Department of Health

Reactor Site Selection
Arnold J. Moen
Washington State Department of Health

State Standards
Warren R. Lawson, M.D.
Minnesota Department of Health

Florida Environmental Surveillance Objectives
Wallace Johnson
Florida Department of Health & Rehabilitative Services

California Environmental Surveillance Objectives
John Heslep, Ph.D.
California State Department of Public Health

TUESDAY, APRIL 28, 1970
CHURCHILL ROOM

1:30 p.m. - PANEL: POWER REACTORS AND THE ENVIRONMENT (continued)

Emergency Plans
Leroy E. Stratton
Illinois Department of Health

Nationwide Reactor Surveillance
Ernest D. Harward
Division of Environmental Radiation
Bureau of Radiological Health

3:45 p.m. - BREAK

CONFERENCE OF RADIATION CONTROL PROGRAM DIRECTORS

4:00 p.m. - ANNUAL MEETING AND ELECTION OF OFFICERS

COMMITTEE MEETINGS

7:30 p.m. - PROBLEM SESSIONS

WEDNESDAY, APRIL 29, 1970
CHURCHILL ROOM

8:30 a.m. - PARTNERSHIP PROJECTS
Moderator: Donald E. Van Farowe
Michigan Department of Public Health

1970 X-ray Exposure Study
Joseph N. Gitlin
Division of Medical Radiation Exposure
Bureau of Radiological Health

Registry of Radiation Incidents:

Electronic Products
Loren F. Mills, D.D.S.
Division of Biological Effects
Bureau of Radiological Health

Radioactive Materials
Gail D. Schmidt
Division of Medical Radiation Exposure
Bureau of Radiological Health

Visibility for Radiation Control Programs
John C. Villforth, Director
Bureau of Radiological Health

WEDNESDAY, APRIL 29, 1970
CHURCHILL ROOM

10:00 a.m. - BREAK

COMMITTEE MEETINGS

10:15 a.m. - PROBLEM SESSIONS

12:00 - LUNCH

1:30 p.m. - CLOSING SESSION
Moderator: Hanson Blatz
New York City Department of Health

Committee Reports
Committee Chairmen

Summary and Closing Remarks
James W. Miller, D.D.S.
Office of Regional Operations
Bureau of Radiological Health

4:00 p.m. - ADJOURNMENT

NOTES

We wish to acknowledge the assistance
in local arrangements provided by:

Florida Division of Public Health
W.T. Sowder, M.D., Director
C.L. Nayfield, M.D., Administrator,
Radiological and Occupational Health Section
●
Palm Beach County Health Department
C.L. Brumback, M.D., Director

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